PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY

OF

EDINBURGH.

FOR THE PROMOTION OF ZOOLOGY AND OTHER BRANCHES OF NATURAL HISTORY.

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SESSION 1906-1907.

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PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXXXVI.

At the opening meeting, held on *Monday, 22nd October* 1906, the retiring President, Mr WILLIAM EVANS, F.F.A., F.R.S.E., delivered the following address on "Our Present Knowledge of the Fauna of the Forth Area."

GENTLEMEN,—The question which I am going to ask, and in a manner attempt to answer, this evening is, What progress has been made in the investigation of the Fauna of the Forth Area? The answer will, perhaps, best be given in the form of a statement of what has been done in each group up to the present time. But first let me indulge in a few prefatory remarks of a general nature.

No apology need be made for bringing this subject before the Royal Physical Society of Edinburgh, for, as its *Proceedings* amply testify, this Society more than any other has been, and still is, actively associated with the investigation of the local fauna. When the Wernerian Natural History Society—by whose members so many of the pioneer observations in this matter were made—was dissolved, its zoological (and geological) section was in 1858 incorporated with the Royal Physical, at whose meetings zoology in its local, as well as in its wider aspects has ever since occupied a prominent place. For a time, too, our Society annually appointed committees on "Marine Zoology" and "Entomology," for the purpose of investigating these branches of the natural history of this neighbourhood; and it is a fact that the chief workers at the fauna of the district have, with scarcely an exception, been at some period of their careers either Fellows of this, or members of the Wernerian Society. Thus our *Proceedings* and the *Memoirs* of the incorporated Society are singularly

rich in papers and records relating to the Fauna of the Firth of Forth and the surrounding country.

Our present and, as I hope to show, wonderfully extensive knowledge of the Fauna of the Forth Area is the outcome not of any organised scheme, but of the independent labours of many naturalists and collectors during the past hundred or more years; indeed, its origin may be placed as far back even as Sir Robert Sibbald's time, about the end of the seventeenth century. Consequently, its growth has been very erratic and uneven; in the main, no doubt, a reflection of the progress of British zoology in general, though too often lagging far behind. All the same, much has been accomplished. A mere list of the names of those who have furnished records for the building up of the faunal account of this area, and of the channels through which they have made known their observations, would fill many pages. The Proceedings, etc., of Societies, Magazines of Natural History, and other serial literature, most of them running to many volumes, into which papers or notes have found their way, number over fifty, while equally numerous are the separately published books and monographs from which records are to be culled. If this voluminous literature could be exhaustively examined, and the records systematically extracted, arranged, and published, no one would rejoice more than myself; but I confess I see no immediate prospect of such an undertaking being begun, far less completed.[1] Co-operation among the societies and individuals interested in the subject, and the command of sufficient funds, are essential, and neither is easily secured, though I do not say unobtainable should an enthusiast take the matter up. Meanwhile, we suffer from the want of a guide to what has been done in the faunistic investigation of the area, and it is with the object of in some degree supplying this want, and pointing the way to further work, that the present review has been prepared. Although all the likely sources of information have been referred to at one time or another, and I hope without anything of importance being overlooked, it must not be supposed that I have gone methodically through each,

[1] Should such a bibliography ever be undertaken, it would be a great pity to confine it to one area: it should embrace all the Scottish areas.

volume by volume. Indeed, in the case of some of the publications, the few records they contain seem to me hardly worth the trouble of so elaborate a search.[1] Early records in obscure groups are often of doubtful value; still, it is always a satisfaction to be aware of their existence. Besides the published data, there are a number of unpublished lists and odd records of my own included in the following survey. I had hoped to see most of these in print before this time, but for several reasons have found the realisation of that hope impossible. An effort to secure their early publication will, however, be made.

Apart from the gain in knowledge of records, an intimate acquaintance with the literature of this subject is well worth cultivating. It helps us, for one thing, to appreciate the work of others who have gleaned in the same field before us, and to avoid over-estimating the value of our own. Much of the earlier section of it has also the merit of being delightfully written, for many of the naturalists of last century had the happy faculty of recording their observations in a manner that gives a charm to their writings, without detracting in the least from their scientific value. I refer, of course, to such works as Dalyell's 'Powers of the Creator,' Forbes's 'Starfishes,' and Macgillivray's 'British Birds.' It does one good to get into touch, as it were, with these and the many other gifted naturalists of the past, whose names are associated with the study of the Fauna of "Forth," and have made the district classic ground. Interest in the work is thereby doubled, as I know from experience. Thus, besides the interest in the event itself, the examination of a stranded cetacean, for instance, never fails to remind me of the work of Sibbald and Knox (I do not forget that of Sir Wm. Turner, who happily is still with us); similarly, a rare or interesting bird carries my thoughts back to Macgillivray, his correspondent Durham Weir, and Robert Gray; an uncommon fish, to Neill and Parnell; a crustacean, to Harry

[1] For records since 1864 there is, of course, the *Zoological Record* to help us; but, the investigation being a local one, it would be a mistake to suppose that all we need to know is to be found there. A list of the publications consulted is not here printed, partly to save space, but mainly as being unnecessary in view of the system of direct references, by way of footnotes, given in the detailed portion of the paper.

Goodsir, the young naturalist who perished with the Franklin Expedition; a parasitic worm, to John Goodsir; a planarian, to Sir John Dalyell; an echinoderm, a medusa, or a mollusc, to Edward Forbes; a zoophyte, to Strethill Wright and Allman; a sponge, to Grant; an insect, according to its kind, to James Wilson of Woodville, Duncan, Greville, Lowe, Logan, and others. Clearly, it is to the sure advantage of our subject to keep green the memory of these men: it adds greatly to the pleasure of the pursuit, and stimulates to further effort.

Possibly there are still some who are disposed to doubt the utility of such local faunal work, but happily, as I think, the day when it may have been necessary to bring forward arguments in its favour is behind us. The "Local List," it has been well said, when carefully and scientifically drawn up, is the useful handmaid of many a science[1]; and we need have no fear that our "Forth" list will be allowed to remain in its present incomplete state through want of interest on the part of serious workers, as I have sometimes heard suggested. Of course, he who would engage in the work should bear in mind that the more attractive groups have already been largely overtaken, and that if he wishes to make his mark now he must leave the beaten track and devote his energies to some obscure or neglected, *i.e.*, so-called "unpopular" group; but if he will work at a "popular" one, he must select some neglected section or aspect of it.

Here let me say that I fully appreciate the superiority of a scientific zoological (as part of a biological) survey, which aims at finding out not only what animals are in a district, but everything connected with their occurrence there, over any purely faunistic inquiry; and I only wish it could be said that the inauguration of such a survey of Scotland was within sight. No doubt, the scientific department of the Scottish Fishery Board, and the Lake Survey which Sir John Murray is conducting, are to some extent doing the work; but before it can be said to have been properly taken in hand, an organisation planned and manned on lines similar to our Geological Survey will require to be constituted.[2]

[1] Rev. A. Thornley, *Trans. Nottingham Naturalists' Society*, 1900.

[2] Since the above was written, a thoughtful paper by Prof. Trail of Aberdeen, advocating the formation of a Society to carry out a full survey of the Natural History of Scotland, has appeared in *Ann. Scot. Nat. Hist.*, 1907.

But after all, the difference between a faunal and a zoological survey is relative rather than fundamental—the one leads up to the other, the greater includes the less—and, in the meantime, the former might be made to supply in a not inconsiderable degree the place of the latter, if workers would keep before them the œcological aspect of the subject, and as opportunity offered, note something more than the mere names and localities of the animals they meet with. Date and weather, numbers, sex, condition as regards age, etc., variation from type, environment, associates, photograph of locality, are all points deserving of attention.[1] "The real progress of natural history," wrote Forbes in advocating the investigation of our native animals, "must ever depend on the detailed examination of the beings gathered around us by the laws of geographical distribution, living and mutiplying in their destined homes and habitats."[2]

Among the purposes which reliable and comprehensive local faunas are calculated to serve, two very obvious ones may be cited here. Firstly, in view of the changes that are continually taking place in the animal life around us, they provide a basis of comparison between one period and another; secondly, they supply those facts of distribution which help the student of our country's fauna the better to understand its origin and characteristics. Thus, by comparing the "Forth" lists of to-day with former ones, we may note, for instance, the disappearance of a number of predaceous mammals and birds, several fishes, and some interesting butterflies; and conversely, the appearance and increase of certain other birds and animals. The disappearance of predaceous species, such as the Polecat and the Hen Harrier, is easily explained; but why the butterflies have gone is by no means so apparent. Then, in addition to the ordinary eastern type of fauna, we find in our lists a sprinkling of boreal species, and the south-eastern element can also be detected. These are enticing subjects which, however, I cannot enlarge upon now; and in any case our knowledge of many groups

[1] And in the case of rare or little known species and facts the recorder does well to mention any previous records he knows of, if for no other reason than to facilitate the work of future compilation.

[2] *History of British Star-fishes* (1841), p. 267.

is, as yet, too meagre to permit of safe conclusions. Of the many circumstances detrimental to our fauna, the smoke and dust of the mining districts, and the ashes and other refuse from the ever increasing shipping in the Firth, are probably among the worst.

As has already been said, the investigation of the fauna of the Forth area has proceeded in a more or less haphazard manner, and not as the even work of any organised scheme for the purpose.[1] A detailed historical review of the subject as a whole, which might be tedious, seems hardly necessary seeing that the stages in our knowledge of each group of animals will be separately traced when we come to deal with each in order. A brief sketch may, however, be here given.

In the main, the marine and terrestrial sections of the fauna have been investigated independently. The good progress made in the former has been largely due to the influence of the Chair of Natural History in our University, several of the occupants of which have been eminent marine zoologists; while the Museum has been more a source of encouragement in the other field. Passing over a few 15th and 17th century records relating to the birds on the Bass (see under *Aves*), we may start with Sir Robert Sibbald's list of "Animals or living Creatures" in the Firths of Forth and Tay, published in 1710, in his *History of Fife and Kinross*, along with which may be mentioned his *Phalainologia Nova* of 1692.[2] During the remainder of the 18th century, there are practically no records other than a few relating to mammals and birds in the old 'Statistical Account of Scotland.' Early in the 19th century, the Wernerian Natural History Society, with which the names of Prof. Jameson and Dr Patrick Neill are so intimately linked, came into existence; and for several decades did much to foster the investigation of our local fauna.[3] Among the papers contributed to its *Memoirs* were

[1] At the suggestion of Sir John Murray, the Scottish Natural History Society a few years ago undertook a scheme for the investigation of the Forth valley, as explained by Dr Marion Newbigin in the *Scot. Geograph. Mag.* for Dec. 1901, but no direct effort to draw up or extend faunal lists was, it appears, to be made.

[2] In his *Historia Animalium in Scotiâ* (1684) localities are seldom given.

[3] For a notice of the Wernerian Society, see Address by Prof. J. H. Balfour in vol. ii. of our *Proceedings*. From 1807 to 1817 Neill contributed "Monthly Memoranda in Natural History" to *The Scots Magazine*.

those by Neill (1808), and Parnell (1837), on the fishes of the Forth; Jameson, on the "Vermes" (1809, the year in which Darwin was born!); Laskey, on the Mollusca (1809) Stewart, on the insects generally (1809); and Duncan, on the Coleoptera (1831). It was during this period, too, and the succeeding years down to about 1860, that the numerous records on the marine side, due to Sir John Dalyell, R. E. Grant, Prof. E. Forbes, John and Harry Goodsir, Strethill Wright (whose papers on zoophytes enrich the early volumes of this Society), Prof. Allman, and others, were being made. In 1862 a list of Mollusca and some other invertebrates inhabiting the Firth of Forth, drawn up by Dr M'Bain, was published in Wood's *East Neuk of Fife*. In 1872 the German North Sea Expedition paid a visit to the mouth of the Forth, adding materially to the local data. The next stage in the progress of the marine section was the publication in 1881, in our *Proceedings* and separately, of Drs G. Leslie and W. A. Herdman's important catalogue, 'The Invertebrate Fauna of the Firth of Forth.' In this most useful work, which was undertaken by the authors—then connected with the University class of Practical Zoology—at the suggestion of Prof. Sir Wyville Thomson, are given not only the personal records of the authors themselves and several contemporary naturalists, but also practically all those that had been previously chronicled. The species and varieties enumerated in this catalogue, now of course much out of date, are 648. As a guide to what was known up to that time it is indispensible. From the marine laboratory of the Scottish Meteorological Society, for a time established at Granton, additional records, by Dr Henderson and Messrs Cunningham and Ramage, were soon furnished; but the farther investigation of the marine fauna of the Forth we owe mainly to the Scientific Committee of the Fishery Board for Scotland, of which Prof. Cossar Ewart was the first convener. In this connection it will suffice to mention here, Dr T. Scott's "Catalogue of the Crustacea" (796 species, of which 657 are marine), just published as parts of our *Proceedings*.

To return to the terrestrial section; following the papers in the *Wernerian Memoirs* already mentioned, and passing over some short lists of land shells and insects by Neill,

Greville, and others, the land-marks during the next half-century are: Wilson and Duncan's Coleoptera (1834), Macgillivray's lists of Birds (1837 and 1839), Lowe and Logan's Lepidoptera (1852), Murray's records of Coleoptera (1853), Turnbull's 'Birds of East Lothian' (about 1855 and 1867), and the "Insecta Scotica" (1872-1885)—Lepidoptera, by Buchanan White, by whom the scheme was originated;[1] Coleoptera, by D. Sharp; and Trichoptera, by King and Morton. These were followed by Roebuck's "Census" of the Land and Fresh-water Mollusca (1890), my own account of the Mammals (1891), and of the Reptiles and Batrachians (1894), and Carpenter and Evans's Spiders (1894). The past dozen years has been a period of increasing activity, during which much new ground has been broken by myself and others, details of which will be found under Protozoa, Rotifera, Arachnida, Myriapoda, Insecta, and other groups.

The Firth of Forth, as I regard it, is bounded to the east by a line drawn from Fife Ness to St Abb's Head. The Firth and the drainage area thus enclosed constitute the "Forth" Area (*cf.* sketch map in previous vol.). To show distribution properly, the area should be sub-divided into lower, middle, and upper Forth.

I now pass on to the consideration of the various groups in detail, concluding with a summary which shows at a glance how the investigation now stands. The groups are taken in the order in which they are arranged in the *Cambridge Natural History.*[2]

PROTOZOA.

To begin at the beginning, then, let us see what has been done among the Protozoa, that great assemblage, or "Phylum," of unicellular creatures which the microscope has revealed to us.

The ordinary generic types, such as *Amœba, Difflugia, Arcella, Euglena, Ceratium, Paramœcium, Stylonychia, Vorticella, Epistylis,* and so on, are well enough known to every microscopist, but very few, I imagine, have ever attempted to master the various forms under each which do duty as

[1] It is apt to be forgotten that Dr White was the first to mark off Scotland into the now well-known drainage areas.

[2] For vol. iv., not yet published, I have only the announcement to go by.

"species." At any rate, I have met with few records except in the case of those marine testaceous Rhizopods (I here use the term in the wide sense, equalling the class Sarcodina) known as the Foraminifera, though it is quite possible there may be some others in microscopical journals which I have not yet been able to examine fully.

Forty to fifty years ago Dr Strethill Wright—one of the most accurate observers of his day—described or recorded in our *Proceedings* (vols. i.-iii.) and elsewhere, a number of marine forms, both of Rhizopods and Infusorians (Ciliata and Suctoria), from the Firth of Forth.[1] One of the former, it is interesting to recall, he named *Boderia turneri*, after Mr (now Sir) Wm. Turner.[2] Another was the gigantic (for a Rhizopod) *Gromia oviformis*, Duj.: *Spirillina perforata*, *Dendrophrya radiata*, and *D. erecta*, three Foraminifera, were also recorded by him.[3] Of Infusoria his records seem to include eight or nine from the estuary.

Prior to 1870 H. B. Brady examined the mud of the upper part of the estuary at Bo'ness for Foraminifera, and incorporated the results in his important paper on the brackish-water species, published in the *Annals and Magazine of Natural History* for that year (p. 273). Prof. F. E. Schulze's Report on the Foraminifera collected by the German North Sea Expedition of 1872,[4] also contains a number of records from the shores of the Firth of Forth. These two sets of records, and a number of fresh ones from material dredged by themselves off Inchkeith, and examined by Mr F. G. Pearcey, enabled Leslie and Herdman to include a list of

[1] For a list of Dr Strethill Wright's papers and communications, see obituary notice of him by Dr J. A. Smith, in *Proc. Roy. Phys. Soc. Edin.*, vol. iv. p. 102. Besides our *Proceedings*, the *Edin. Phil. Jour.*, the *Ann. and Mag. Nat. Hist., etc.*, should be consulted for records by Dr Wright.

[2] *Proceedings*, vol. iii. p. 153. I am not aware that *Boderia turneri* has again been seen. Prof. Hartog tells me it is given as probably a "Reticulose" in Delage and Herouard's 'Traité de Zoologie Concrète,' vol. i. (1896). *Cf.* also Rhumbler, "Systematische Zusammenstellung der recenten Reticulosa," in *Arch. f. Protistenkunde*, vol. iii. (1903), Heft 2., and Bütschli, Protozoa, in Bronn's 'Thier-Reich.'

[3] *Proceedings*, vol. ii. pp. 82, 273, 276. *D. erecta* was found again in the original locality (Granton Old Quarry) by David Robertson (T. Scott, *Fishery Board's Eighth Rept.*, pt. iii. p. 317).

[4] *Jahresbericht der Kommission, etc.*, 1874.

35 Foraminifera—the only Protozoa they give—in their "Invertebrate Fauna" of the Firth, communicated to this Society in 1880-81.[1] One addition, *Astrorhiza limicola*, Sand., was reported by Dr J. R. Henderson in 1884.[2] Since then the list has been greatly extended by the naturalists to the Fishery Board, Dr T. Scott adding 48 species,[3] and Mr Pearcey a further contingent of apparently no less than 71.[4] So far as I am able to make out, there have been at one time or another about 160 Rhizopods (practically all Foraminifera) recorded from the estuary, and a good many more—say what would bring the list up to 200 at least—no doubt remain to reward further work. No Radiolaria have been recorded, and it may well be that none occur.

Of non-marine Rhizopods (Sarcodina) there have been but few records. In a paper presently to be referred to, Scott and Lindsay mention half a dozen species obtained in a pond on the Braid Hills, and a few years earlier (1891) Dr Scott recorded four from Loch Leven.[5]

During the years 1896-1898, Messrs T. Scott and J. Lindsay made a systematic investigation of the micro-fauna (and flora) of the "Upper Elf Loch," the tarn on the top of the Braid Hills, and in an excellent paper published in the *Transactions of the Edinburgh Field Naturalists and Microscopical Society*, vol. iii., they give (pp. 381, 382) a list of the Protozoa, which I understand were identified for them by Mr John Hood of Dundee. This list contains 69 names, (I here exclude *Chætonotus*), 6 of them belonging, as above-mentioned, to the Rhizopoda, 30 to the Flagellata,[6] 31 to the Ciliata, and 2 (*Podophryœ*) to the Suctoria; and it is, we may reasonably suppose, fairly representative of the Protozoan life in other ponds in the area. To test

[1] *Proceedings*, vol. vi. p. 201, and Reprint p. 29.

[2] *Ib.*, vol. viii. p. 308. For Bennie's "raised sea-bottom" lists, see vols. x. p. 293, xii. p. 27.

[3] *Reports* (7*th and* 8*th*) *of Fishery Board for Scotland* for 1888 and 1889.

[4] "Notes on the Marine Deposits of the Firth of Forth, and their Relation to its Animal Life," with lists of animals obtained, *Trans. Nat. Hist. Soc. Glasgow*, vol. vi. (n.s.) pt. ii. (1902), pp. 217-251.

[5] *Fishery Board's* 9*th Report*, part iii. p. 274.

[6] *Volvox* and its allies (5 species) are included in the micro-flora.

this latter point, however, further investigations ought to be made. Other ponds and pools, besides those at Braid Hills, from which I have myself examined "dips," and found to be rich in similar microscopic life, are the old marl-pit at Davidson's Mains, a pond at Duntarvie near Winchburgh, and a pool on Dumbarnie Links near Largo. I do not presume, however, to record the forms observed. To be of any value, the records must come from persons possessing special knowledge of the groups. Strethill Wright, it may be mentioned, described a Ciliate, *Stentor castaneus*, Wr., from the pond at the Edinburgh Botanic Garden,[1] whence also *Ophrydium versatile*, Ehr., has been recorded by W. R. M'Nab.[2]

Struck with the results obtained by Penard from sphagnum, etc., in Switzerland, I have been endeavouring, during the past year, to find out what Sarcodina belonging to the groups Rhizopoda (*s. str.*) and Heliozoa are present in our moor-pools. With this object I sought the assistance of Mr James Cash, author of the Ray Society's recent volume on *British Fresh-Water Rhizopods*, and of Mr James Murray, of the Scottish Lake Survey, to both of whom my best thanks are due for supplying me with lists of the species found in material which I sent them from time to time. Dr Penard, of Geneva, has also kindly favoured me with a report on a parcel of bog-moss sent to him. Samples of sphagnum and other wet moss from sea-level to mountain-top have in this way been examined, and a list of over 60 Rhizopoda and 4 Heliozoa obtained. The small yield of Heliozoa is rather surprising, I have tabulated Mr Cash's reports for the different localities. and they seem in harmony with the view that these organisms are little affected by altitude, so long as their immediate environment is suitable. The species reported by Penard and Murray are also shown in the Table. Cash regards a *Nebela* detected by him as an undescribed species, while *Zonomyia violacea*, Nüssl., *Nebela tenella*, Pen., and *Placocysta jurassica*, Pen., are additions to the British list.

[1] *Proc. Roy. Phys. Soc. Edin.*, vol. ii. p. 33.

[2] *Ib.*, vol. iii. p. 46. In vol. iii. (p. 233) Dr Stevenson Macadam mentions 5 Ciliates (generic names only) and 1 Flagellate (*Euglena viridis*) from the Water of Leith.

Table I.

List of Non-Marine Sarcodina found by Messrs J. Cash, J. Murray, and Dr E. Penard in damp moss (chiefly Sphagnum) from the Forth Area, sent to them by W. Evans during 1905-6.

Name.	Noted by Cash during 1906—48 forms.									Penard, 1906.	Murray, 1905, etc.
	Luffness Marsh (in Hypna) August.	Thornton Moss, Fife. August.	Pentland Hills. July.		Bog at Aberfoyle. July.	Ben Ledi. September.		Stuc-a-Chroin. September.		Auchencorth Moss, 900 feet. October.	Various localities.
			Bavelaw Moss.	Cobbinshaw Moss.		At 1500 feet.	Summit, 2875 feet.	2500 feet.	Summit, 3189 feet.		
RHIZOPODA.											
Div. Lobosa.											
Amœba limax, Duj.,	×									×	
A. guttula, Duj.,								×			
A. proteus, Rös. (=*princeps*, Perty),						×					
A. terricola, Greeff (=*verrucosa*, Ehr., in part),											×
A. striata, Pen.,	×										
Pseudochlamys patella, Clap. and Lachm.,	×										
Zonomyia violacea, Nüssl.,										×	
Difflugia piriformis, Perty,								×			×
D. capreolata, Pen.,											×
D. bacillifera, Pen.,										×	×
D. acuminata, Ehr.,											×
D. a. var. *inflata*, Pen.,											×

D. constricta, Ehr. (=*[illegible]*, Wall.),	×				×		×		×		×
Centropyxis aculeata, Stein.,	×				×					×	×
C. lævigata, Pen.,			×	×						×	
Pontigulasia bigibbosa, Pen.,					×						×
**Lecquereusia spiralis* (Ehr.),											×
**L. modesta*, Rumbl.,											×
Hyalosphenia papilio, Leidy,		×	×	×	×			×		×	×
H. elegans, Leidy,		×			×					×	×
Nebela collaris, Leidy,			×	×			×	×		×	×
N. bohemica, Tar.,											×
N. tubulosa, Pen.,											×
N. barbata, Leidy, var. (=*lageniformis*, Pen. ?),								×			×
N. carinata, Leidy,				×	×	×				×	×
N. marginata, Pen.,											×
N. flabellulum, Leidy,		×	×			×		×			×
N. bursella, Vedj.,		×	×	×	×	×	×	×	×	×	×
N. militaris, Pen.,		×	×	×			×	×		×	×
N. crenulata, Pen.,				×		×		×			×
N. vitræa, Pen.,									×		
N. tenella, Pen.,				×	×	×		×		×	
N. sp. nov. (Cash MS.),		×		×		×	×	×	×		
Quadrula symmetrica, F. E. Schul.,	×				×		×				×
Heleopera petricola, Leidy,		×	×	×	×	×		×		×	×
H. p. var. *amethystea*, Pen.,					×						×
H. rosea, Pen.,						×					
H. cyclostoma, Pen.,											×
Arcella vulgaris, Ehr.,	×	×			×						×
A. discoides, Ehr.,	×									×	×

* See notes on following page.

TABLE I.

LIST OF NON-MARINE SARCODINA found by Messrs J. CASH, J. MURRAY, and Dr E. PENARD in damp moss (chiefly Sphagnum) from the Forth Area, sent to them by W. EVANS during 1905-6.

NAME.	Noted by Cash during 1906—48 forms.									Penard, 1906.	Murray, 1905, etc.
	Luffness Marsh (in Hypna) August.	Thornton Moss, Fife. August.	Pentland Hills. July.		Bog at Aberfoyle. July.	Ben Ledi. September.		Stuc-a-Chroin. September.		Auchencorth Moss, 900 feet. October.	Various localities.
			Bavelaw Moss.	Cobbinshaw Moss.		At 1500 feet.	Summit, 2875 feet.	2500 feet.	Summit, 3189 feet.		
RHIZOPODA.											
Div. LOBOSA.											
Amœba limax, Duj.,	×									×	
A. guttula, Duj.,								×			
A. proteus, Rös. (=*princeps*, Perty),						×					
A. terricola, Greeff (=*verrucosa*, Ehr., in part),											×
A. striata, Pen.,	×										
Pseudochlamys patella, Clap. and Lachm.,	×										
Zonomyia violacea, Nüssl.,										×	
Difflugia piriformis, Perty,								×			×
D. capreolata, Pen.,											×
D. bacillifera, Pen.,										×	×
D. acuminata, Ehr.,											×
D. a. var. *inflata*, Pen,											×
D. elegans, Pen.,										×	
[illegible]											
D. globulosa, Duj.,		×			×						×
D. arcula, Leidy,											×
D. constricta, Ehr. (=*marsupiformis*, Wall.),	×				×		×		×		×
Centropyxis aculeata, Stein.,	×				×					×	×
C. lævigata, Pen.,			×	×						×	
Pontigulasia bigibbosa, Pen.,					×						×
**Lecquereusia spiralis* (Ehr.),											×
**L. modesta*, Rumbl.,											×
Hyalosphenia papilio, Leidy,		×	×	×	×			×		×	×
H. elegans, Leidy,		×			×					×	×
Nebela collaris, Leidy,			×	×			×	×		×	×
N. bohemica, Tar.,											×
N. tubulosa, Pen.,											×
N. barbata, Leidy, var. (=*lageniformis*, Pen. ?),								×			×
N. carinata, Leidy,				×	×	×				×	×
N. marginata, Pen.,											×
N. flabellulum, Leidy,		×	×			×		×			×
N. bursella, Vedj.,		×	×	×	×	×	×	×	×	×	×
N. militaris, Pen.,		×	×	×			×	×		×	×
N. crenulata, Pen.,				×		×		×			×
N. vitrœa, Pen.,									×		
N. tenella, Pen.,				×	×	×		×		×	
N. sp. nov. (Cash MS.),		×		×		×	×	×	×		
Quadrula symmetrica, F. E. Schul.,	×				×		×				×
Heleopera petricola, Leidy,		×	×	×	×	×		×		×	×
H. p. var. *amethystea*, Pen.,					×						×
H. rosea, Pen.,						×					
H. cyclostoma, Pen.,											×
Arcella vulgaris, Ehr.,	×	×			×						×
A. discoides, Ehr.,	×									×	×

* See notes on following page.

TABLE I., *continued.*

Name.	Noted by Cash during 1906—48 forms.									Penard, 1906.	Murray, 1905, etc.
	Luffness Marsh (in Hypna) August.	Thornton Moss, Fife. August.	Pentland Hills. July.		Bog at Aberfoyle. July.	Ben Ledi. September.		Stuc-a-Chroin. September.		Auchencorth Moss, 900 feet. October.	Various localities.
			Bavelaw Moss.	Cobbinshaw Moss.		At 1500 feet.	Summit, 2875 feet.	2500 feet.	Summit, 3189 feet.		
A. artocrea, Leidy,											×
A. catinus, Pen. (=*vulgaris*, var. *compressa*, Cash),	×		×	×		×			×	×	
Div. Filosa.											
Pamphagus hyalinus (Ehr.),					×				×		
Cyphoderia ampulla (Ehr.) (=*margaritacea*, Schl.),					×						×
**Euglypha alveolata*, Duj.,											×
E. ciliata (Ehr.),											×
E. strigosa, Leidy,		×	×	×	×		×	×		×	
**E. brachiata*, Leidy,											×
Placocysta spinosa, Leidy,					×						×
P. jurassica, Pen.,				×							
Assulina seminulum (Ehr.),				×	×	×				×	×
A. s. var. *scandinavica*, Pen.,										×	
A. minor, Pen.,			×	×	×	×		×	×	×	×
Sphenoderia lenta, Schlumb.,					×						
S. dentata, Pen.,	×										
Trinema enchelys (Ehr.) (=*acinus*, Duj.),	×	×					×	×			×

A. flavum (Archer), ...		×	×	×	×	×		×		×	
A. wrightianum, Arch., ...					×	×					
HELIOZOA.											
Actinophrys sol, Ehr., ...			×			×					×
Actinosphærium eichorni, Ehr., . .											×
**Acanthocystis turfacea*, Cart., . . .											×
A. myriospina, Pen. (?), ...	×										
67 Species and 3 Varieties.	14	14	12	16	24	16	11	19	9	21	43

* These were found by Mr Murray in Loch Vennachar in 1902. For the localities in the case of the last column in the table, see paper by Mr Murray in *Ann. Scot. Nat. Hist.*, 1907, pp. 93-96.

The seven species of Rhizopoda recorded by Scott and Lindsay in the papers referred to on page 10 are *Amœba proteus*, Leidy (+*A. princeps*, Ehr.), *A. radiosa*, Ehr., *A. schultzii*, Pritch. (=*A. verrucosa*, Ehr. (?), see Pritchard's 'Infusoria,' 4th ed., 1861, p. 550), all from Upper Elf Loch, Braid Hills; *Difflugia globulosa*, Duj., and *D. pyriformis*, Perty, Loch Leven and Elf Loch; *D. corona* and *D. marsupiformis*, Loch Leven.

Dr J. H. Ashworth tells me *Entamœba histolytica*, Schaud. has occurred in man, in Edinburgh, but it was certainly imported.

TABLE I., *continued.*

NAME.	Noted by Cash during 1906—48 forms.									Penard, 1906.	Murray, 1905, etc.
	Luffness Marsh (in Hypna) August.	Thornton Moss, Fife. August.	Pentland Hills. July.		Bog at Aberfoyle. July.	Ben Ledi. September.		Stuc-a-Chroin. September.		Auchencorth Moss, 900 feet. October.	Various localities.
			Bavelaw Moss.	Cobbinshaw Moss.		At 1500 feet.	Summit, 2875 feet.	2500 feet.	Summit, 3189 feet.		
A. artocrea, Leidy,											×
A. catinus, Pen. (=*vulgaris*, var. *compressa*, Cash),	×		×	×		×			×	×	
Div. Filosa.											
Pamphagus hyalinus (Ehr.),					×				×		
Cyphoderia ampulla (Ehr.) (=*margaritacea*, Schl.),					×						×
**Euglypha alveolata*, Duj.,											×
E. ciliata (Ehr.),											×
E. strigosa, Leidy,		×	×	×	×		×	×		×	
**E. brachiata*, Leidy,											×
Placocysta spinosa, Leidy,					×						×
P. jurassica, Pen.,				×							
Assulina seminulum (Ehr.),				×	×	×				×	×
A. s. var. *scandinavica*, Pen.,										×	
A. minor, Pen.,			×	×	×	×		×	×	×	×
Sphenoderia lenta, Schlumb.,					×						
S. dentata, Pen.,	×										
Trinema enchelys (Ehr.) (=*acinus*, Duj.),	×	×					×	×			×
T. complanatum, Pen.,								×			
[illegible]											
Corythion dubium, Tar.,	×	×		×	×		×	×	×		
Amphitrema stenostoma, Nüsl.,					×	×				×	
A. flavum (Archer),		×	×	×	×	×		×		×	
A. wrightianum, Arch.,					×	×					
HELIOZOA.											
Actinophrys sol, Ehr.,			×			×					×
Actinosphærium eichorni, Ehr.,											×
**Acanthocystis turfacea*, Cart.,											×
A. myriospina, Pen. (?),	×										
67 Species and 3 Varieties.	14	14	12	16	24	16	11	19	9	21	43

* These were found by Mr Murray in Loch Vennachar in 1902. For the localities in the case of the last column in the table, see paper by Mr Murray in *Ann. Scot. Nat. Hist.*, 1907, pp. 93-96.

The seven species of Rhizopoda recorded by Scott and Lindsay in the papers referred to on page 10 are *Amœba proteus*, Leidy (+*A. princeps*, Ehr.), *A. radiosa*, Ehr., *A. schultzii*, Pritch. (=*A. verrucosa*, Ehr. (?), see Pritchard's 'Infusoria,' 4th ed., 1861, p. 550), all from Upper Elf Loch, Braid Hills; *Difflugia globulosa*, Duj., and *D. pyriformis*, Perty, Loch Leven and Elf Loch; *D. corona* and *D. marsupiformis*, Loch Leven.

Dr J. H. Ashworth tells me *Entamœba histolytica*, Schaud. has occurred in man, in Edinburgh, but it was certainly imported.

Beyond the eight or nine by Wright, previously alluded to, I am not aware of any records of marine Flagellata or Infusoria (Ciliata and Suctoria) from the area. Yet a considerable number may be expected to occur. The summer phosphorescence one occasionally sees on the Firth is most likely in large measure due to the presence of certain pelagic Dinoflagellata—*Ceratium* or *Peridinium* probably—but I have met with no statement on the point.[1]

Of the parasitic Protozoa, there is scarcely a record definite enough for faunal purposes. It is known that Trypanosomes (blood-inhabiting Flagellata), Gregarines (*Monocystis*, etc.), Coccidiidæ (*Coccidium* of the rabbit, for instance), and other Sporozoa, etc., occur, but they require to be scientifically determined and recorded. There is a record of Eels from a stagnant pond on the Isle of May, having "the cornea opaque, and attacked with Gregarines and other organisms."[2] Dr Ashworth tells me he has found *Monocystis agilis* and another species in earthworms from an Edinburgh garden, and *Opalina ranarum* in a local frog. A glance at Minchin's long list of Sporozoa and their hosts, in Ray Lankester's *Treatise on Zoology*, will show what a field for investigation there is here for anyone prepared to take it up.

The following statement will help to make clearer the extent of our ignorance of the Protozoa of the area, and the great possibilities of further work among them. The figures given under "estimated number," while in some degree of the nature of guesses, have been arrived at after careful consideration of all the available data, and will, it is believed, prove to be within rather than over the mark. The Mycetozoa (Myxomycetes, etc.), with their "fructifications," and the Volvocaceæ among the Flagellata, I willingly leave to the botanists. Nor have I taken cognisance of the Proteomyxa, the small group to which *Plasmodiophora brassicæ*—the cause of the well-known "finger and toe" disease in turnips—belongs.

[1] In this connection *cf.* a paper by Prof. M'Intosh in *Zoologist* for 1906. "Infusoria" appears several times in the table of observations made on board the "Garland" (*Fish. Bd. Rpts.* for 1892, etc.).

[2] G. Sandeman, *Proc. Scot. Micr. Soc.*, vol. i. p. 172.

Class and Sub-Class.	Number recorded from Forth.	Estimated Number in Area.
Sarcodina :—		
Rhizopoda, ...	225	About 300
Heliozoa, ...	4	20– 25
Radiolaria, ...	0	Doubtful if any
Sporozoa, ...	2 or 3	200–250
Flagellata (Mastigophora), . . .	31	120–150
Infusoria :—		
Ciliata, ...	40	150–200
Suctoria (Acinetaria), . . .	3	10– 15
Total Protozoa, . .	306	say 800–900

PORIFERA.

Much work remains to be done among the Sponges before anything like a satisfactory list can be drawn up. A few early records are due to Dr R. E. Grant (1826, etc.)[1] and Dr Fleming (*British Animals*, 1828). In Bowerbank's *British Spongiadæ*, "Firth of Forth" is cited as a locality in the case of 12 species, 6 being in vol. ii. (1866) and 6 in vol. iv. (1882); and several, including the type of *Amorphina paciscens*, Schmidt, were collected in the Firth, in 1872, by the German North Sea Expedition.

Leslie and Herdman, in their 'Invertebrate Fauna of the Firth of Forth' (1881), give only 12 Porifera, but 5 of those specified in vol. ii. of Bowerbank's Monograph, namely, *Hymeniacidon thomasii*, Bwk. (from Black Rocks, Leith, Capt. Thomas, R.N.), *H. incrustans*, Johnst., *Isodictya cinerea* (Grant), *Chalina cervicornis* (Johnst.), and *C. seriata* (Grant), do not seem to be accounted for. I leave, however, the question of possible synonyms, and the revision of the nomenclature in general, to the compiler of the next list.[2] From vol. iv. (1882) of the Monograph we get 2 additions, *Halichondria coralloides*, Bwk. (found by D. Robertson), and *Ascandra complicata* (Mont.) = *Leucosolenia botryoides*, E. & S. (obtained by Allman). Then J. R. Henderson, in 1884 (*l.c.*), recorded 3 further additions, namely, *Ascandra variabilis*, Haeckel, *Isodictya fucorum* (Johnst.), and *Suberites ficus*

[1] *Edin. Phil. Jour.*, xiv. (1826); *Edin. New Phil. Jour.*, i. (1826), and ii. (1827); etc. [2] *Cf.* in this matter, Hanitsch, *Trans. Liverp. Biol. Soc.*, viii. p. 173, and re. Fresh-water species, *Irish Nat.*, 1895.

(Esp.). The last-named has also been obtained by F. G. Pearcey;[1] and *S. domuncula* (Nardo), though not new to the list, has been found by T. Scott to be moderately common in the Firth.[2] The fresh-water sponges, *Spongilla lacustris*, auctt., and *S.* (*Ephydatia*) *fluviatilis*, auctt., occur in the district. I have known both for many years in the Union Canal about Slateford.[3] In Grant's time one of them (he used the name *S. friabilis*) was abundant at Lochend, Edinburgh (*cf.* his paper in *Edin. Phil. Jour.*, xiv. p. 270).

It would appear, then, that at one time or another some 24 "species" of Porifera have been recorded from the Forth area. That this is a very incomplete record cannot be doubted. Many additions to the list would, we may feel sure, reward a diligent search by one possessing the requisite knowledge and opportunities. What the probable number of Forth Porifera may be it is hard to say. According to the list of Sponges given by Canon Norman in the 4th volume of Bowerbank's "Monograph," about 260 forms are British (I exclude a score pertaining to the Channel Islands), half of them being known from Scottish waters; but a large proportion of these cannot be expected to occur in an estuarine area such as ours. Eighty would probably be too sanguine an estimate, but there can hardly, I think, be less than fifty.

CŒLENTERATA AND CTENOPHORA.

During the period when Dalyell, Forbes, Strethill Wright, Allman, and others were enriching the literature of marine zoology by their discoveries, many Cœlenterates were recorded from the estuary of the Forth. Especially was this the case as regards that section (the Hydroids) of the class Hydrozoa which Wright and Allman studied to such good purpose.[4] When Leslie and Herdman, who were themselves

[1] *Trans. Nat. Hist. Soc. Glasgow*, vi. (n.s.), p. 244.

[2] *Trans. Edin. Field Nat. and Micros. Soc.*, v. p. 198.

[3] Specimens of both from this locality, in Oct. 1906, have been verified for me by Mr R. Kirkpatrick of the British Museum.

[4] "Observations on British Zoophytes," by Strethill Wright, in vols. i.-iii. (1854-1866) of *Proc. Roy. Phys. Soc. Edin.*, *Jour. of Anat. and Phys.* (i., 1867, p. 332), *Edin. New Phil. Journ.*, etc. 'Gymnoblastic Hydroids,' *Ray Soc*, 1871, by Prof. Allman; and earlier papers in *Ann. and Mag. Nat. Hist.* (1859, etc.), and elsewhere. Forbes's 'British Naked-eyed Medusæ,' 1848, contains few records from the Forth.

keenly interested in this fascinating but difficult group of animals, drew up their lists of Firth of Forth Invertebrates, they were able to catalogue 109 forms of Cœlenterata (including Ctenophora [1]). These they arranged as follows :—

		Class.
Hydroida, ...	85	=Hydrozoa.
Medusoid Gonophores, .	9	
Acalepha, ...	2	= Scyphozoa (large Jelly-fish).
Alcyonaria, ...	4	= Anthozoa or Actinozoa (Sea-Anemones, etc.).
Zoantharia, ...	7	
Ctenophora, ...	2	

Since the date of that Catalogue, 1881, 10 additional marine species have been recorded by Dr Henderson, Dr Scott, and Mr Pearcey, as detailed below. Grouped as above, they are :—Hydroida, 7; Acalepha, 1; Zoantharia, 2. In 1890 I found a Lucernarian (*Haliclystus auricula*, I believe), one of the sedentary Scyphozoa, near North Berwick; and a third Ctenophore has probably occurred. To the first section there must also be added 2 fresh-water species, namely, *Hydra viridis*, L., and *H. oligactis*, Pall. (=*fusca*, L.). The former, which is in Scott and Lindsay's list of animals found in the Upper Elf Loch (*l.c.*), is common (I have obtained it from the Union Canal, Elf Loch, ponds at Davidson's Mains, Winchburgh, and Largo Links, Loch Leven, etc.), and I have taken the other in a pool at Callander (Sept. 1906). We have thus a total of 123 forms recorded, but most of the "Medusoid Gonophores" are probably only the sexual individuals of species included in the list of "Hydroida," in which case they will require to be deducted.

The list of Forth Cœlenterata is in need of revision in the light of present-day knowledge, and a diligent worker might still count on adding considerably to it. As the list shows, and I can corroborate it from my own experience, the Anthozoa (Sea-Anemones, etc.) and the Scyphozoa (true Jelly-fish) are poorly represented in the Firth of Forth. I have often examined the large Jelly-fishes cast on the beach in the autumn, and never succeeded in detecting any species but the common *Aurelia aurita* and *Cyanœa capillata.*

[1] Prof. Hickson (*Cambr. Nat. Hist.*, vol. i.) regards the Ctenophora as a separate Phylum.

The two Ctenophores, *Pleurobrachia pileus* (Fab.), and *Beroë cucumis*, Fab. (= *ovata* of our lists), I have occasionally met with in abundance in the sea near Gullane, etc. Dalyell took a specimen of "*Beroë pileus*" at Queensferry in 1819, and had 4, from Forbes, from the coast of Fife.[1] Leslie and Herdman give no earlier record for this than that of the German North Sea Expedition of 1872. No Siphonophora have been recorded from the Firth of Forth, nor should we expect any to occur.

In connection with our Anthozoa, mention should be made of the famous sea-anemone "Grannie," which died on 4th August 1887, at the advanced age of 66 (see paper "On the Duration of Life in Cœlenterates," by Ashworth and Annandale, in *Proc. Roy. Soc. Edin.*, 1904, xxv. p. 295).

The following are the recorded additions to Leslie and Herdman's list—I give the names exactly as published :—

Cœlenterata ; *Sertularia fusca*, Johnst. (J. R. Henderson, *Proc. Roy. Phys. Soc.*, viii. p. 115), *S. tenella*, Ald. (*id.*, p. 309), *Coryne van benedenii*, Hincks (*id.*, p. 308), *Heterocordyle conybearei*, Allm. (*id.*, p. 308, and Pearcey, *Trans. Nat. Hist. Soc. Glasgow*, 1900-1901, p. 244), *Campanularia hincksii*, Ald. (Henderson, *l.c.*, p. 308), *Halecium* sp. (*id.*), *Diphasia pinaster*, Ell. and Sol. (Pearcey, *l.c.*, pp. 241, 244), *Haliclystus auricula*, Fab. (Evans, see p. 15), *Rhizostoma* sp. (Pearcey, *l.c.*, p. 244), *Bunodes coronata*, Penn. (*id.*, pp. 231, 233), *Cerianthus lloydii*, Gosse (Scott, 10*th*, 1891, *Fish. Bd. Rept.*, pt. iii., p. 266).

Ctenophora ; Dalyell's *Beroë bilobata* (? = *B. infundibulum*, Fab.) probably came from the Firth of Forth (cf. *Rare and Remarkable Animals of Scotland*, ii. p. 254).[2] *Cydippe pomiformis*, Patt., recorded from the Forth by Forbes and J. Goodsir (*Brit. Assoc. Rpt. for* 1839), and by Pearcey (*l.c.*, pp. 228, 231) is now regarded as a synonym of *Pleurobrachia pileus* (Fab.), to which, doubtless, should also be referred the "small variety of *Cydippe*, distinguished by the rufous colour which tinged the bases of the tentacular cirri," recorded by Wright in our *Proceedings* (i. p. 169) as swarming in the Firth in June 1856. Prof. J. Arthur Thomson, in an article in Pollock's *Dictionary of the Forth*, 1891 (p. 156), alludes to swarms of *Beroë cucumis*, no doubt the same species as Leslie and Herdman, Pearcey (*l.c.*, p. 228), and others have recorded under the specific name *ovata*.[3]

[1] *Rare and Remarkable Animals of Scotland*, ii. (1848), p. 257; and Fleming's *British Animals* (1828), p. 504.

[2] Since this paper was read, *Bolina infundibulum* (Fab.), and some interesting Hydromedusæ—including *Æquorea*—have been recorded from the Firth by Dr Ashworth and myself ; see our paper farther on in this vol. An *Æquorea*, probably from the Forth, was described by Wright in vol. ii., p. 316.

[3] For synonymy of the Ctenophora, *cf.* Chun, *Die Ctenophoren der Plankton Expedition*, 1898.

ECHINODERMATA.

No group has been more popular with our marine zoologists than the Echinoderms—Star-fishes, Sea-urchins, and Sea-cucumbers—the study of which Forbes's classic 'History' of the British species, published in 1841, has done so much to promote. Most of the pioneer Forth naturalists took an interest in them and have left records, but none studied them to such good purpose as Edward Forbes and John Goodsir. A "Notice of the Echinodermata of the Firth of Forth," by J. Foggo, published in the *Edinburgh Journal of Science* for 1825, is of some local interest though of little scientific value. Coming to more recent times, we find F. M. Balfour, Leslie, and Herdman giving attention to the group. In their valuable Catalogue of Firth of Forth Invertebrates, the last two naturalists record 32 species (I deduct *Astrophyton linckii* and *Asterias violacea*), to which Dr Scott has since added two, namely, *Luidia sarsi*, Düb. and Kor., and *Brissopsis lyrifera* (Forbes).[1] The *Brissopsis* is a specially interesting discovery, for, while abundant on the west coast of Scotland, this Heart-urchin is rare on the east coast. Scott has also been able to give a fresh record for *Hippasterias phrygiana* (Parel.) = *H. plana* (Linck).[2] Mr Pearcey, who has an intimate knowledge of Echinoderms, has published a number of useful records of species, none, however, new to the list, which he dredged in the Firth of Forth while engaged on the Fishery Board's investigations.[3] By shore-collecting and a little dredging in bygone years, I have myself gained some knowledge of the group.

Thus it may safely be assumed that our knowledge of the Echinodermata of the Firth of Forth is tolerably complete, and although the list comprises only 34 species, I feel sure there are very few to add. The fact that *Echinus acutus*, Lam., has been got near St Andrews, *E. elegans*, Düb. and Kor., off Montrose, and *Echinocardium pennatifidum*, Norm., off Holy Island, no doubt gives hope of one or other of

[1] *Proc. Roy. Phys. Soc. Edin.*, xi. p. 82; *Sixth, Eighth, and Ninth Fishery Board Reports;* and *Ann. Scot. Nat. Hist.*, 1892, p. 50.

[2] *Proc. Roy. Phys. Soc. Edin.*, xi. p. 82; and *Ann. Scot. Nat. Hist.*, 1892, pp. 49, 50.

[3] *Trans. Nat. Hist. Soc. Glasgow*, vi. (n.s.), pt. ii. (1892), pp. 228-244.

these forms turning up within the seaward limits of this area. Another possible addition is *Ophiura robusta* (Ayres).[1] Further attention might with advantage be given to the Holothurians.

Considerable changes in nomenclature have taken place since Leslie and Herdman's list was published five-and-twenty years ago; and for this reason, as well as for the incorporation of the fresh data, a revised list seems desirable. I have therefore prepared one, which it is proposed to publish separately, on the basis of Jeffrey Bell's *Catalogue of the British Echinoderms,* 1892.

PLATYHELMINTHES.

(Turbellaria, Trematoda, Cestoda.)

From a popular we pass on to an unpopular, and consequently much neglected group. The Flat-worms, as a whole, have never been systematically sought for here, and records are few and scattered. As a field for further investigation, few groups are more promising.

Turbellaria.—Sir John G. Dalyell's classical observations on the habits and life-histories of Planarians, both fresh-water and marine, were made in this district,[2] but many of his species—among them *Planaria edinensis* from "the discharge from the Well-house Tower, near the castle of Edinburgh"—cannot now be identified, at anyrate with certainty. On this point von Graff's *Monographie d. Turbellarien,* 1882, etc., and F. W. Gamble's "Contribution to a Knowledge of British Marine Turbellaria," 1893,[3] should be consulted. Dr Möbius, in his Report on the "Vermes" obtained by the German North Sea Expedition, records the Polyclad *Leptoplana atomata* (Müll.) from near the Bass Rock, and in November 1905 I found half a dozen examples of *L. tremellaris* (Müll.) (*Pl. flexilis,* Dalyell) under a stone between tide-marks at Morrison's Haven. To the land and

[1] *Cf.* Hoyle, *Proc. Roy. Phys. Soc.*, viii. and x., for distribution of British Ophiuroidea and Echinoidea.

[2] 'Observations on some interesting Phenomena in Animal Physiology, exhibited by several species of Planariæ,' Edin., 1814; and 'Powers of the Creator,' ii., 1853.

[3] *Quart. Jour. Micr. Sci.*, xxxiv. (n.s.) pp. 433-528, 1893.

fresh-water Triclads I have myself recently been giving some attention, and have a short paper on them nearly ready for publication. *Rhynchodemus terrestris* (Müll.)—probably our only indigenous terricolous Triclad—is not uncommon,[1] and the exotic *Placocephalus* (*Bipalium*) *kewensis* (Moseley) seems to be established in a few greenhouses.[2] The following fresh-water species, *Planaria lactea*, Müll., *P. alpina*, Dana (*P. arethusa*, Dalyell), and *Polycelis nigra*, Ehr., are all common: *P. cornuta*, Schm. (*felina*, Dll.) I have also found, and the marine *Gunda ulvæ*, Örst. (once at Dunbar). Of the minute Rhabdocœlida there must be many both marine and fresh-water. Dalyell knew a number from the east of Scotland, mainly no doubt from "Forth," but as often as not he omits to state the locality, so that, apart from the difficulty of identifying his species, his works furnish comparatively few records.[3]

When the Turbellaria of "Forth" have been properly investigated, I anticipate a list of from 40 to 50: at present we know of little more than a dozen. From St Andrews Bay, close to the mouth of the Forth, Professor M'Intosh has recorded a number of marine species.[4]

TREMATODA.—The Trematodes, like other parasitic worms, have not yet received the attention they deserve. The best known is the liver-fluke, *Distomum hepaticum*, with whose intricate life-history every student of zoology is familiar. Of

[1] W. Evans, *Ann. Scot. Nat. Hist.*, 1905, p. 57.

[2] A specimen (from a greenhouse at Corstorphine) was exhibited by Professor J. Arthur Thomson at a meeting of this Society, 20th January 1897 (*Proceedings*, xiii. p. 396); and it has been known for a number of years in hot-houses at the Royal Botanic Garden (Dr Stewart MacDougall, *Trans. High. and Agric. Soc.*, 1905, p. 280). Dr Calman states (*Ann. S. N. H.*, 1902, p. 233) that a large planarian which he has examined from the Botanic Garden approaches most closely to *Rh. hallezi*, v. Graff.

[3] Taking von Graff (*op.cit.*) as a guide, we may admit the following as "Forth" records of Rhabdocœlids:—*Microstoma lineare*, Örst. (*P. falcata*, Dll.), Lochend; *Mesostoma rostratum*, Ehr. (*P. velox*, Dll.), near Linlithgow ?, (Loch Leven, July 1906, W. Evans); *Vortex viridis*, M. Sch. (*P. graminea*, Dll.), near Linlithgow, without doubt; *Derostoma unipunctatum*, Ö. (*P. fodinæ*, Dll.), old quarry at Fenton Tower, Haddingtonshire. A few others are less certain. Gamble (*l.c.*) gives "Firth of Forth" as the locality for several of Dalyell's unlocalised marine Planarians. *Convoluta paradoxa*, Ö. (*P. haustrum*, Dll.), was from Eyemouth, which is scarcely in the Firth of Forth: I have, however, found it abundantly at Dunbar, and also at North Berwick.

[4] 'Marine Invertebrates and Fishes of St Andrews,' 1875.

the numerous fish-infesting species, Dr T. Scott has recorded over 20 from Scottish waters, only two, however, being from the Firth of Forth. The following seem to be all the Trematodes for which there are Forth records. It would be easy to name others which must occur, and have probably been observed though not recorded.

Tristomum molæ, Blanch.—From short sun-fish captured in the Firth of Forth in 1890; Scott, 19*th Rep. Fish. Bd. Scot.*, pt. iii. p. 144.

Octobothrium merlangi (Kuhn)—From gills of whiting, Firth of Forth; Scott, 13*th Rep. F. B. S.*, pt. iii. p. 172. Dr Ashworth tells me he has had this from a local haddock.

Polystomum integerrimum, Fröh.—Has been found here in the common frog (Ashworth).

Onchocotyle appendiculata (Kuhn)—Several taken by me from gills of a Greenland shark stranded at North Queensferry, 10th April 1906; Evans, *Ann. Scot. Nat. Hist.*, 1906, p. 187.

Distomum hepaticum, Abild.—The "liver-fluke" occurs in both sheep and oxen. Professor S. Stockman, in *Proc. Scot. Micr. Soc.*, ii. p. 110, writes: "During the past few years, at the Edinburgh abattoir, I have examined about 110 livers from oxen harbouring the *Distoma hepaticum*." Dr Stewart MacDougall records finding the "redia" stage in specimens of the small mollusc, *Limnæa truncatula*, taken from a trough in a field near the Pentland Hills "with sheep all around" (*Trans. High. and Agric. Soc.*, 1903, p. 286). Liver-rot in sheep has at various times come under my notice on marshy ground on the Pentlands. [April 1908; Mr Little, Crosswood Reservoir, sends me specimens of the fluke from a sheep, one of several he has lost there from this cause during the past few months.]

Hemiurus communis, Odhn.—Dr W. Nicoll has found this in a bullhead (*Cottus scorpius*) I sent him from North Berwick in Oct. 1908; and *Podocotyle atomon* (Rud.) in 3-spined sticklebacks, and a viviparous blenny from rock-pools, Dunbar, in May.

The redia of a *Distomum*—probably a species occurring in water-fowl—has been found by Dr Ashworth in *L. peregra* from the marl-pit at Davidson's Mains. A *Distomum* ?, is recorded from *Sagitta*; Scott, 14*th Rep. Fish. Bd. Scot.*, p. 165.

Cestoda.—Finding scarcely any printed local records of Tape-worms, I have applied to several friends likely to be in possession of specimens or unpublished data, with the results noted below. I am especially indebted to Prof. Gofton and Mr R. G. Linton, Royal Veterinary College, Edinburgh, for procuring me specimens of this and other kinds of parasitic worms from domestic animals, and to Dr J. H. Ashworth for checking my determinations and supplying other records. To

Dr Lovell Gulland I am indebted for valuable information regarding the parasites of man, creatures which one is pleased to think are less prevalent than formerly. When the Cestodes of our fishes, birds, and *feræ naturæ* generally are known, this list will probably be trebled.

Schistocephalus solidus, Crepl.—From body cavity of stickleback, Loch Leven, June 1890 (T. Scott, *9th Rep. Fish. Bd. Scot.*, pt. iii. p. 273).

Bothriocephalus latus, Brems., ?—Several (larvæ) in alimentary canal of trout, Loch Leven, June 1890 (T. Scott, *l.c.*). Dr Gulland has never seen this species in the human subject here, and considers that when it does occur it must certainly be imported.

B. punctatus, Rud.—Several from bullheads (*Cottus scorpius*), North Berwick, Oct. 1908: identified for me by Dr W. Nicoll.

Diplocotyle, sp.?—From trout, Loch Leven, April 1904 (Dr Ashworth).

Tetrarhynchus reptans, Rud. (*Gymnorhynchus horridus*, J. Goodsir)—In liver of short sun-fish captured at Culross in 1840 (J. Goodsir, *Edin. New Phil. Jour.*, xxxi. (1841) p. 9). In liver and lateral muscles of short sun-fish captured off Anstruther, 6th Sept. 1856 (T. S. Cobbold, *Intellectual Observer*, ii. (1863) p. 82).

Tænia serrata, Goeze—Common. From dogs, Edinburgh, June, etc., also from cat; from dog, Pentlands, March. Larvæ from mesentery of rabbit (Ashworth).

T. saginata, Goeze (*mediocanellata*, Küch.)—From Edinburgh patients (Ashworth). Dr Gulland writes me that as regards the Cestodes in man this is the most common here, "and has been distinctly on the increase since we began to feed our phthisis patients on raw beef."

T. solium, Rud.—Of this Dr Gulland says, "*Solium* is very much rarer; in fact, almost unknown here."

T. crassicollis, Rud.—From cat, Edinburgh (Dr MacDougall).

T. cœnurus, Küch.—I have seen no specimen of this species, but it must occur seeing that "staggers," the disease which the larva causes in sheep, is occasionally in evidence.

T. serialis, Baill.—Cysts from groin region of rabbit (Ashworth).

T. echinococcus, v. Sieb.—Is "occasionally seen, but mostly in hospital cases from the country. It is very rare indeed in Edinburgh people. Most of the hospital cases come from the north, from Shetland, perhaps, in particular" (Dr Gulland, *in lit.*).

T. pectinata, Goeze—Common in wild rabbits. Pentlands, August (from W. F. Little); identification confirmed by Dr A. E. Shipley.

Anoplocephala perfoliata, Goeze—Occasionally troubles horses in the district. Dr Ashworth has shown me a local specimen.

Dipylidium caninum, L. (*cucumerina*, Bloch)—Common in dogs. From terrier, Edinburgh, July, and from cat, August.

Hymenolepis, sp.?—Dr Shipley, Cambridge, tells me he has a

Hymenolepis [since identified as *H. microps* (Dies.) = *H. tetraonis*, Wolffh.[1]] taken from a red grouse from the Pentlands, near Edinburgh.

Drepanidotænia gracilis, Zed.—Larva found encysted in specimen of the Ostracod, *Candona rostrata*, from Duddingston Loch (T. Scott, *Proc. Roy. Phys. Soc. Edin.*, x. p. 314, 1891).

Davainea calva, Baird—Common in grouse. I have seen it at Auchencorth Moss, in June, and have specimens from Crosswood in April Dr Shipley tells me he has it from the Pentlands. [*D. urogalli* (Modeer) is, it appears, an earlier name for this species. *Cf.* Shipley *l.c.*].

Note.—I am not aware that any MESOZOA have been detected here, but seeing several of the Cephalopods, etc., in which they live are found in the Firth of Forth, a few may reasonably be expected to occur.

NEMERTINEA.

Though studied, as to their habits and characters, by Sir John Dalyell,[2] and also to some extent by Harry Goodsir,[3] no one appears to have worked at the Nemertines with the special object of ascertaining what species inhabit the Firth of Forth. With the exception of two species of *Malacobdella*, a genus then associated with the Leeches, they are unrepresented in Leslie and Herdman's 1881 Catalogue of the Invertebrates of the Firth.

The giant of the group,[4] *Lineus* (*Gordius*) *marinus*, Mont. (= *L. longissimus*, Simm., and *Nemertes borlasii*, Cuv.)—the Black Worm of the Newhaven fishermen—was well known to Patrick Neill a century ago.[5] In 1860 some specimens "of enormous length" were procured in the Firth by the Committee of this Society on Marine Zoology,[6] It has since been recorded by Dr T. Scott as comparatively common in the Firth.[7] I have found it several times at North Berwick in

[1] *Cf.* Shipley, Grouse Disease Inquiry, Interim Rept., 1908, p. 66.

[2] *Cf. Powers of the Creator*, vol. ii., 1853.

[3] *Ann. Nat. Hist.*, xv. (1845), p. 377.

[4] Professor M'Intosh says of a specimen got at St Andrews in 1864: "Thirty yards were measured without rupture, and yet the mass was not half uncoiled" (*Monog. Brit. Annelids*, Part I.)

[5] Neill, *Scots Mag.*, Nov. 1807, p. 804, where one 42 ft. long is recorded; and Jameson, *Wernerian Memoirs*, i. p. 557.

[6] *Proc. Roy. Phys. Soc.*, ii. p. 240.

[7] *Ann. Scot. Nat. Hist.*, 1893, p. 185.

roots of "tangle." Dr Scott has also recorded *Cerebratulus angulatus* (O. F. Müll.)=*Serpentaria fragilis*, H. Goodsir, and *Gordius fragilis*, Dalyell, from the vicinity of Largo Bay, in February 1894.[1] There can be little doubt that both Goodsir and Dalyell had this interesting worm from the mouth of the Firth, although they do not expressly say so, and Johnston[2] mentions a specimen in the British Museum labelled "Firth of Forth, Lieut. Thomas, R.N." When shore-collecting, I have obtained a number of other species, but one or two only have as yet been identified.

The following are all the Nemertinea for which I find definite Forth records:—

(Nomenclature as in M'Intosh's *Monograph.*[3])

Amphiporus lactifloreus (Johnst.)—North Berwick, August 1906; Dalmeny; Charlestown (W. E.).

Nemertes neesii (Örst.)—One from Firth of Forth in Brit. Mus. (Johnston's *Catalogue*, p. 29, as *Serpentaria fusca*).

N. assimilis (Örst.)—Obtained in vicinity of the Bass Rock by the German North Sea Expedition of 1872 (Möbius, *Jahresbericht der Commission*, etc., ii. and iii., 1875, p. 155).

Lineus marinus (Mont.)—See above. Also from Black-rocks, Leith, Dr Greville (Johnston's *Catalogue*, as *L. murenoides*).

L. gesserensis (O. F. Müll.)—Shore near Charlestown, February 1905 (W. E.).

L. bilineatus (D. Ch.)—Dalyell had specimens of this from a Cellardyke fisherman (*Powers of the Creator*, ii. p. 71, as *Gordius tœnia*).

Cerebratulus angulatus (O. F. M.)—See above.

Carinella annulata (Mont.)—Specimen from Firth of Forth in Brit. Mus. (Johnston's *Catalogue*).

Cephalothrix linearis (Rathke)—Dalmeny shore (W. E.).

Malacobdella grossa (O. F. M.)—Off Elie, Leslie and Herdman (*Invert. Fauna*, 1881, p. 64).

M. valenciennœi (Blanch.)—In *Mya truncata*, Firth of Forth (Johnston's *Catalogue*, pp. 35 and 302).

From the indications of distribution given in Professor M'Intosh's account of the "Nemerteans" (*British Annelids*, Part I.), I think we should expect at least twenty species to occur within the limits of the Firth of Forth.

[1] *Ann. Scot. Nat. Hist.*, 1894, p. 118.

[2] *Catalogue of Non-Parasitic Worms*, 1865, p. 28.

[3] *Monog. Brit. Annelids*, Part I. *Nemerteans;* Ray Soc., 1873-74.

NEMATHELMINTHES.

(Nematoda, Nematomorpha, and Acanthocephala.)

Of the Nematodes, or Thread-worms and their allies, our knowledge is exceedingly meagre. A number of the parasitic forms are no doubt known to occur with us, but there is scarcely a record in the ordinary natural history literature, and it has not been possible to search for reports of cases in medical and veterinary journals, where perhaps a few might have been found, or to make much inquiry for unpublished data. The minute free-living species, of which there must also be many, offer an excellent field for research. New forms, it is quite certain, would reward the investigator. When looking for Rotifers in damp moss sent by me from this neighbourhood, Mr James Murray has found half a dozen species of microscopic Nematodes, some of them belonging not only to new species, but to a new genus and family. Mr Murray has recorded the three known forms,[1] but is holding over the others till he sees what Dr Richters, who is studying the type, publishes. On the basis of a rough estimate of the number of British Nemathelminthes, I should think 150 not too many to expect from this district.

Nematoda.—The following are the few Nematodes for which I have local records. Imported foreign species, such as the miner's worm (*Ancylostomum duodenale*), of which Dr Lovell Gulland tells me he has seen several cases here, are purposely omitted :—

Ascaris lumbricoides, L.—Common in man (Dr Gulland, *in lit.*).

A. mystax, Zed. (*marginata*, Rud.)—Common in dogs. I have received specimens from Messrs Gofton and Linton.

A. communis, Dies.—Taken from two bullheads (*Cottus scorpius*) from North Berwick, Oct. 1908. For the identification of this and the other forms from fishes, I am indebted to Dr W. Nicoll.

A. clavata, Rud.—Dalyell's *A. gadi*, from stomach of cod in Edinburgh (*Powers of the Creator*, ii. (1853) p. 93), was probably this species, as perhaps are also specimens I have from Sperlings (*Osmerus eperlanus*) from Alloa, Dec. 1907.

A. fabri, Rud.—In Oct. 1907, I took half-a-dozen specimens of this from a Greater Weever (*Trachinus draco*) caught off Anstruther.

[1] "Some interesting Nematodes in the Forth Area," *Ann. Scot. Nat. Hist.*, 1906, p. 164.

Oxyuris vermicularis, L.—Quite common in man (Dr Gulland).

Strongylus pergracilis, Cobb.—Common in the cæca of grouse. Mr Shipley has recently had it from grouse killed on the Pentlands. I have seen another Thread-worm in the droppings of grouse on Auchencorth Moor.

S. filaria, Rud.—Several from lungs of a sheep, Crosswood, Pentlands, April 1908.

Sclerostomum equinum, Müll. (*Strongylus armatus*, Rud.)—Specimens from a horse have been sent to me by Mr Linton.

S. tetracanthum, Dies.—In 1906 a young horse on a farm at Crail nearly succumbed to an attack of this small red worm, and Dr Ashworth tells me he has specimens from the Edinburgh district.

Ollulanus tricuspis, Leuck.—From cat, Edinburgh (W. Stirling, *Quart. Jour. Micr. Sci.*, 1877, p. 145).

Syngamus trachealis, v. Sieb.[1]—The so called "fork-worm," the cause of "gapes" in poultry and other birds, is common in this district, being especially troublesome among young pheasants. In some places, as in Dalmeny Park, it also causes considerable mortality among young thrushes and blackbirds.

Trichocephalus trichiurus, L. (*dispar*, Rud., *hominis*, Gmel.)—Dr Gulland informs me he has only once seen a case of this here.

Trichina spiralis, Owen—Encysted in abundance in the muscles of a rat caught in Edinburgh (A. B. Stirling, *Jour. Anat. and Phys.*, vi. (1872) p. 425). Very rare here in the human subject (Dr Gulland).

Rhabditis, sp.?—A minute Nematode belonging to this genus was plentiful in the lining of a rook's nest from Dunipace, May 1905 (W. E.).

Tylenchus devastatrix, Kuhn.—This agricultural pest, the Eel-worm of clover sickness, occurs in the district.

Bunonema richtersi, Jäg.—In sphagnum from Thornton Moss, Fife, Dec. 1905 (Murray, *l c.*).

B. reticulatum, Richt.—In wet moss, Thornton, Hopetoun, and Bridge of Allan, Dec. 1905 (Murray, *l.c.*); also in sphagnum from near top of Ben Ledi, Sept. 1906 (W. E.).

Desmoscolex minutus, Clap.—Got by me in seaweed at Morrison's Haven, Nov. 1905 (Murray, *l.c.*).

A Nematode has been noted by Scott in *Sagitta* from the Firth of Forth (*Fish. Bd. Rept.* for 1895, p. 165).

NEMATOMORPHA.—The horse-hair worm, or "hair-eel"—*Gordius aquaticus* of authors—occurs here, but is not plentiful. I have found it in Braid Burn, the Tyne at East Linton, etc.; and Dr Ashworth has shown me a specimen that came through a water-tap at Aberdour in 1906. Sir John Dalyell (*op. cit.*) figures one which was extracted from the throat of "a person in Edinburgh belonging to the establishment of the Royal Bank," who had swallowed it with a draught of

[1] *Fasciola trachea*, Montagu, *Mem. Wern. Soc.*, i. (1811) p. 197.

water. Surely more than one species of Gordiidæ ought to occur with us.[1]

ACANTHOCEPHALA.—With the exception of *Echinorhynchus gigas*, Goeze, of which Dr Ashworth has shown me a specimen from the intestine of a pig, I have no records under this sub-order. But no doubt a number of other species, such as *E. proteus* in fresh-water fishes, *E. acus* in whiting, etc., are to be found in the district. [I have since got *E. acus*, Rud., in bullheads (*Cottus scorpius*) from North Berwick, Oct. 1908; identified by Dr Nicoll, who has recently published in *Ann. and Mag. Nat. Hist.*, two papers on the Entozoa of marine fishes and shore-birds at St Andrews.]

CHÆTOGNATHA.

The only representative of this small class of pelagic animals that has been recorded from the Firth of Forth is *Sagitta bipunctata*, Q. and G. It was obtained by the German Expedition of 1872 off St Abb's Head, and has since been found commonly by the naturalists to the Fishery Board—Dr Scott and Mr Pearcey—within the Forth, at various stations as far up as the neighbourhood of Inchkeith.[2] It occasionally occurred in the tow-net, Dr Scott tells me, in such numbers as to be a positive nuisance. Perhaps further investigation will show that more than one species of Chætognath occurs in our waters. A useful table of known species is given in vol. ii. of the *Cambridge Natural History*.

ROTIFERA.

Although in a general way Rotifers are favourite objects of study with the microscopist, comparatively little has been done in determining and recording the species to be found in this district. As a class they abound almost everywhere from the sea-shore to the hill-tops, a handful of damp moss, water-weed, or algæ, seldom failing under proper treatment to yield numerous individuals and not a few species.

[1] I have since obtained a second species not yet identified.

[2] Scott, *Ann. Scot. Nat. Hist.*, 1892 and 1893; Pearcey, *Trans. Nat. Hist. Soc. Glasgow*, vi. (n.s.), pt. ii. (1902) pp. 228-244. *Cf.* also Table of Observations made on board the 'Garland' during 1892, etc., in the *Fishery Board's* 11th, etc., *Reports*, part iii.

In their paper on the micro-flora and micro-fauna of the Upper Elf Loch, Braid Hills, 1898, to which I have already had occasion to refer (see p. 10), Scott and Lindsay give a list of Rotifers, identified by J. Hood of Dundee. The number of species there recorded is 97, distributed among the several orders thus—Rhizota, 6; Bdelloida, 11; and Ploima, 80.

With the view of adding to the list of species, and at same time of obtaining records from other localities to show distribution in the area, I arranged, in the beginning of 1905, with Mr James Murray of the Scottish Lake Survey, to collect and send him material for examination for Rotifers. An annotated list of 53 Bdelloida—including the description of a new species—from this material is given in a paper by Mr Murray, published a few months ago in the *Proceedings* of this Society.[1] In a subsequent paper, in the *Annals of Scottish Natural History*,[2] he records the non-Bdelloids (34) he identified, and another Bdelloid; this also includes a new species. An additional Bdelloid and two additional Ploima are recorded in his "Rotifera of the Scottish Lochs" (177 species), just issued.[3] Since the above Forth lists were written, 3 further Bdelloida and 4 Ploima have been collected by me.[4] Of the 58 described Bdelloida identified by Murray, 49 are not in Scott and Lindsay's Elf Loch list; and of the 40 belonging to the other orders, 24 are not in that list.

Thus there are recorded up to the present time 170

[1] "The Bdelloid Rotifera of the Forth Area," *Proc. Roy. Phys. Soc. Edin.*, xvi., No. 5 (1906), pp. 215-229.

[2] "Some Rotifera of the Forth Area, with Description of a New Species," *Ann. Scot. Nat. Hist.*, 1906, pp. 88-93.

[3] *Trans. Roy. Soc. Edin.*, xlv., pt. i. (1906) pp. 151-191. The three species referred to are:—*Philodina megalotrocha*, Ehr., Loch Vennachar; *Triarthra longiseta*, Ehr., Edinburgh district; and *Brachionus pala*, Ehr., Duddingston Loch. The first was previously recorded by Scott and Lindsay in their Elf Loch list.

[4] They are as follows, those already recorded in Scott and Lindsay's list being marked with an asterisk:—*Callidina musculosa*, Milne, Luffness Marsh, July 1906; **Rotifer hapticus*, Gosse, Camilla Loch, Fife, August; *R. macroceros*, Gosse, pool on Largo Links, August; *Notommata torulosa*, Duj., Luffness Marsh, July; **Dinocharis pœcillum*, Ehr., pool on Largo Links, April; *Scaridium longicaudatum*, Ehr., pool on Largo Links, April and August; *Notholca thalassia*, Gosse, pool on Largo Links, April

Additional localities for the following have also been noted:—*Philodina laticeps*, Mur., from *Gammarus pulex*, ditch at Bavelaw, March 1906; *P. macrostyla*, Ehr., Largo Links, April and August; *P. aculeata*, Ehr. ?, with 12 spines, Largo Links, August; *Rotifer trisecatus*, Web., Camilla Loch, August; *Anuræa aculeata*, Ehr., pool by the Teith, Callander, September. There was also found on Largo Links the species previously recorded as *Callidina elegans*, Ehr., but which is now regarded as an undescribed species.

Rotifera from "Forth," and four or five others (species previously known to Mr Bryce, but not yet described) have been met with. That there are many still to be found goes without saying. In his list of Rotifera found within a radius of 20 miles round Dundee (*Scot. Nat.*, 1891), Hood recorded 224 species, including a number from tidal pools in "Tay." If we put the number of species in the Forth area at from 250 to 300, we shall probably be within the mark. Examination of material from rock-pools and other marine habitats is sure to furnish a good many interesting additions. In this connection, a paper by Lie-Pettersen on the Marine Rotifers of Norway (*Bergens Museums Aarbog*, 1905), is well worthy of study. In November 1905 I obtained three species—only one of which (*Philodina flaviceps,* Bryce) was known to Mr Murray—amongst sea-weed at Morrison's Haven. This occurrence of *P. flaviceps* in salt-water is interesting, as, with this exception, it has hitherto been found only in fresh-water habitats. The altitudinal range, too, of the Rotifera deserves attention, microscopic, and consequently, no doubt as a rule, very widely distributed though they be. Last month (September 1906) I brought Mr Murray some sphagnum and other damp moss from the summits of Ben Ledi (2875 feet) and Stuc-a-Chroin (3189 feet), which yielded a number of Bdelloids,[1] including (from both localities) the rare *Callidina incrassata,* a species I had previously found only on the top of the East Cairn Hill, Pentlands.

GASTROTRICHA.

The Gastrotricha, or "hairy-backed animalcules," have never, so far as I know, been studied in this district. What I understand to be *Chætonotus larus,* Müll., is fairly common in stagnant ponds and ditches—I have recently found it in material from the marl-pit near Davidson's Mains, a pond

[1] The species noted were:—*Philodina rugosa,* Bryce, both tops; *P. flaviceps,* Bryce, Ben Ledi; *P. brycei* (Weber), Loch-a-Chroin, 2500 feet; *Callidina hexodonta* (Berg.), Ben Ledi; *C. lata,* Bryce, Loch-a-Chroin; *C. symbiotica,* Zel., Ben Ledi; *C. russeola,* Zel., Stuc-a-Chroin; *C. tetraodon,* Ehr., both tops; *C. incrassata,* Murray, both tops; *C. plicata,* Bryce, both tops; *C. quadricornifera,* Milne, Ben Ledi; *Rotifer vulgaris,* Ben Ledi; *Adineta gracilis,* Janson, Ben Ledi; *A. barbata,* Janson, Ben Ledi and Loch-a-Chroin; *Distyla flexilis,* Gosse, Loch-a-Chroin; *Colurus obtusus,* Gosse, Ben Ledi.

near Winchburgh, and a pool on Largo Links. Scott and Lindsay have recorded it from the Upper Elf Loch, Braid Hills, in their paper mentioned under Protozoa and Rotifera. Besides this species, I have seen other two forms. One, from pool on Largo Links in August last, agreed well with *Chœtonotus maximus,* Ehr., as described and figured in Zelinka's account of the group.[1]

Nineteen Gastrotricha are recorded from Europe, seven of which have, it appears, been detected in Britain, and no doubt there are others awaiting discovery. I should expect five or six at least to occur here.

CHÆTOPODA.

(Polychæta and Oligochæta.)

Our knowledge of the Annelids of Forth is far from satisfactory. Even the deeply interesting and often truly beautiful marine forms, the Polychætes, have never been adequately catalogued, while printed records of Oligochætes are all but non-existent. Professor M'Intosh's splendid Monograph of the British species, now partly published, will, let us hope, stimulate local interest in them.

Polychæta.—Despite its title, very few records pertaining to this group are to be found in Professor Jameson's "Vermes" of the Forth, etc.[2] Sir J. Dalyell made valuable observations on Scottish marine "Bristle-worms," but owing to the want of precise localities, and the difficulty in identifying many of his species, few records definite enough for our purpose can be culled from his writings either. Firth of Forth specimens of about a dozen species, mostly collected by Lieutenant Thomas, R.N., are noted in Johnston's British Museum Catalogue of Non-parasitic Worms, 1865; and a like number are recorded by Möbius in his report on the "Vermes" obtained by the German North Sea Expedition. Leslie and Herdman, confining themselves entirely to the records of Johnston and Möbius and their own observations, give a short list of 27 Polychætes in their "Invertebrate Fauna." Henderson's "Additions" (*l.c.*) make known two others, namely,

[1] *Zeitschr. wiss. Zool.*, xlix., 1890, p. 209.

[2] "A Catalogue of Animals of the class Vermes, found in the Firth of Forth and other parts of Scotland" (*Mem. Wern. Soc.*, i. p. 556, 1809).

Filograna implexa, Berk., and *Tomopteris onisciformis* (Esch.).[1] As the result of studies carried on at the Granton Marine Laboratory of the Scottish Meteorological Society, Messrs J. T. Cunningham and G. A. Ramage, in 1887, laid before the Royal Society of Edinburgh an important paper on "The Polychæta Sedentaria of the Firth of Forth."[2] It deals with 45 species, 33 of which do not appear to have been previously recorded, unless, perhaps, one or two by Jameson or Dalyell.[3] Lastly, in Pearcey's lists (*l.c.*) of animals dredged at the Fishery Board stations in the Forth, a number of useful records of Polychætes are entered, but so far as I can make out only one species, *Glycera dubia*, Blainv., is new to the area.[4] It would thus seem that the Polychæta definitely recorded from Forth waters do not number more than 63. If the group were thoroughly worked, I should not be surprised to find the list more than doubled. Professor M'Intosh thinks this a very moderate estimate: he has recorded over 100 from St Andrews waters. Besides records of additional species, additional information as to species already on the list is much needed.[5] Some notes and specimens of my own may yet be utilised in this connection.

OLIGOCHÆTA.—With the view of preparing a preliminary list of the Oligochætes—the Earthworms and their allies—of the district, I have been collecting them at intervals during the past two or three years, but have not been able to make as much progress with the naming of them as

[1] Dalyell's "*Nereis phasma*" from the Forth (*Powers of the Creator*, ii. p. 260) was probably *T. onisciformis*, which, according to Pearcey (*l.c.*) and Scott (16*th F. B. Rep.*, p. 210) is fairly common. *Serpula filograna*, from near the Bass, was recorded by W. S. Young in 1862 (Rep. Com. Mar. Zool. of this Society, *Proc.*, ii. p. 443).

[2] *Transactions*, xxxiii. (1888) p. 635.

[3] Dalyell (*op. cit.*, p. 150) records *Spio seticornis* from Queensferry; and Wright no doubt also had it from the Forth (*Proc. Roy. Phys. Soc.*, i. p. 238).

[4] The name *Polynoë reticulata*, Clap., appears among Pearcey's records, but I cannot find that there is any such species.

[5] As amplifying the records of *Ammotrypane aulogaster*, Rath. (*Ophelia acuminata*, Örst.), given in L. and H's. list, and by Cunningham and Ramage, there is T. Scott's statement that this Annelid is "all over the Forth where there is a muddy bottom" (*Ann. Scot. Nat. Hist.*, 1893, p. 185). An exceptionally large example of *Phyllodoce laminosa* (*lamelligera*, Johnst.) was recorded by Professor Duns in 1875 (*Proc. Roy. Phys. Soc.*, iv. p. 40).

I should have liked in any family except Lumbricidæ. Of this family—the Earthworms proper—I have now a list of 14 species.[1] As regards the many species of Enchytræidæ occurring both inland and on the shore, only two or three have as yet been made out. *Enchytræus albidus*, Henle, and *Lumbricillus verrucosus* (Clap.), however, are common on the beach at Dalmeny and Aberdour. Similarly, a few only of the aquatic forms have been determined.[2] Altogether, my list of Oligochæta runs to about 30 species, and before it is published there ought to be some to add. Were a qualified zoologist to take the group in hand, he would probably be able, in a comparatively short time, to announce a list of 80 to 100 species.

HIRUDINEA.

It would seem that more leeches were known to Sir J. Dalyell from the ponds and ditches in the neighbourhood of Edinburgh than have been noted since. After a good deal of searching, I have met with only five species, namely:—*Glossiphonia* (*Clepsine*) *stagnalis* (L.), *G. complanata* (L.), *Hemiclepsis tessellata* (Müll.), *Hæmopsis sanguisuga* (L.) (the well-known horse-leach), and *Herpobdella octoculata* (L.), all more or less common, and already on record.[3] Dalyell mentions other three, namely, the medicinal leech, *Hirudo medicinalis*, L. (he figures a specimen from Loch Leven, and also cites a pool near Lake of Menteith as then a locality for the species), *H. vitrina* (probably merely a variety of *tessellata*), and *H. flava* (= *Gl. marginata*. (Müll.)[4]). Un-

[1] I have to thank Mr F. E. Beddard and the Rev. Hilderic Friend for help in naming these. To Dr Michaelsen I am indebted for the determination of *Helodrilus oculatus*, Hoffm. For list see further on in this vol.

[2] In a short paper entitled "Additions to Scott and Lindsay's list of Animals found in the Upper Elf Loch" (*Ann. Scot. Nat. Hist.*, 1905, p. 215, and 1906, p. 57), I recorded *Stylaria lacustris* (L.), *Lumbriculus variegatus* (Müll.), and *Æolosoma hemprichi*, Ehr. S. Macadam (*Proceedings* of this Society, iii. p. 234) and T. Scott (*9th Fish. Bd. Rep.*, pt. iii. p. 273) have recorded *Tubifex rivulorum*, which I have also found abundantly at Lochend, etc. Dr Ashworth has shown me *Chætogaster limnæi* from the marl-pit near Davidson's Mains.

[3] *Cf.* Dalyell's *Powers of the Creator*, ii., 1853; Scott, *9th Rep, Fish. Bd.*, pt. iii. pp. 273 and 275; and Evans, *Ann. S. N. H.*, 1905, p. 215.

[4] *Cf.* W. Houghton, *Ann. and Mag. N. H.*, 1860, p. 248, and *Quart. Journ. Micr. Sci.*, 1861, p. 34.

fortunately the last, which he marks "rare," has no locality assigned to it. *Piscicola geometra* (L.)—a parasite on fresh-water fishes—probably occurs in the area, but as yet I have not been able to obtain a specimen.[1] The skate-leech (*Pontobdella muricata* (L.)), the only species in Leslie and Herdman's Catalogue, is not unfrequent on skates caught in the Firth of Forth.[2] Other three marine species are recorded by T. Scott from fishes captured in the Firth, and a few more—half a dozen say—no doubt still await detection. The three recorded by Dr Scott are:—

Trachelobdella lophii (v. Ben. and Hesse)—From gill-pouches of an angler-fish (*Lophius piscatorius*), 1894 (19*th* (1900) *Fish. Bd. Rep.*, pt. iii. p. 138).

Piscicola scorpii, Fab.—On a bullhead or sea-scorpion (*Cottus scorpius*) (*ib.*, p. 138).

Ichthyobdella sanguinea, Örst.—On catfish (*ib.*, p. 140).

For identification of the fresh-water leeches, I have found a paper by Dr Scharff on the Irish species (*Irish Naturalist* for 1898) most helpful, and the author has been kind enough to examine a few specimens for me himself.

GEPHYREA.

Considering that there are only a dozen known British Gephyrea, we cannot expect more than seven or eight, at most, to occur in the Forth. Five have been recorded, but to understand their status in the area we want more data regarding all of them.

Two specimens of *Priapulus caudatus*, Lam., were obtained long ago at Leith by Dr Coldstream, as mentioned by Fleming[3] and by Forbes,[4] and another was found on the shore near Granton by Dalyell.[5] The undetermined "*Sipunculus*," referred to by Fleming as frequently making its abode in "shells of the Dentalium, in the Firth of Forth,"

[1] Professor M'Intosh records the curious circumstance of an example being found on a *Cottus bubalis* on the sands near the mouth of the Eden (*Marine Invertebrates and Fishes of St Andrews*, p. 114).

[2] Fleming, as *H. verrucosa*, *Wern. Mem.*, ii. 245; C. W. Peach, *Proc. Roy. Phys. Soc.*, ii. 196; *ib.*, 240; etc.

[3] *British Animals*, 1828, p. 492.

[4] *British Starfishes*, etc., 1841, p. 258. This work includes the Gephyrea, which are styled "The Sipunculidæ, or vermigrade Echinodermata."

[5] *Powers of the Creator*, ii. p. 253.

was no doubt *Phascolion* (*Phascolosoma*) *strombi* (Mont.). I have myself occasionally found tooth-shells on the beech at North Berwick that had been so tenanted. Leslie and Herdman cite only three records of Gephyrea in their Catalogue, namely, *Phascolosoma strombi* (Mont.), *Ph. procerum*, Möb.—both obtained near the Bass Rock by the German North Sea Expedition—and the old one of *Priapulus caudatus* from Leith. Dr Scott has added *Echiurus oxyurus*, Pall. (= *E. pallasii*, Guér.), and given a fresh record for the *Priapulus*, from stomachs of fishes taken in the Forth.[1] More recently, Pearcey (*l.c.*) reports another addition, namely, *Phascolosoma vulgare* (Mont.) [Blainv. ?]—one from west of the Isle of May in 20 to 30 fathoms—and a further occurrence of *Ph. strombi*.[2] One wonders whether *Golfingia macintoshii*, Lank., the type of which was got off Montrose, might not be found in the outer waters of the Firth.

PHORONIS.

In 1856 Dr Strethill Wright described in our *Proceedings*[3] two "Tubicolar Animals," to which he gave the names of *Phoronis hippocrepia* and *Ph. ovalis* respectively. Three examples of the first were found on a stone to which a lithophyte was attached, received from Ilfracombe, Devon, and a colony of the second occurred in a decayed oyster shell, the habitation also of a sponge (*Cliona celata*), dredged from the Firth of Forth, near Inchkeith. *Phoronis ovalis*, Wright, is regarded by some as probably only a young form of *Ph. hippocrepia*, Wright, but for the present it must, it seems to me, be treated as distinct. The genus, of which only 12 species are known,[4] is an isolated and highly interesting one, whose systematic position is still uncertain. I am not aware of any further record of this remarkable animal from our waters, but the larval form (Actinotrocha) of a *Phoronis* was captured in the Forth by Dr Cobbold,[5] and has occasionally been taken in the tow-net off Dunbar (*fide* Ashworth).

[1] *9th. Rep.* (for 1890) *Fish. Bd. Scot.*, pt. iii. p. 332.

[2] Pearcey also records *Sipunculus bernhardus?* In reference to this, it may b pointed out that *S. bernhardus*, Forbes = *S. strombi*, Mont. + *S. dentalii*, Gray.

[3] Vol. i. pp. 165-167; also *Edin. New Phil. Jour.*, iv. (1856) p. 313.

[4] *Cf.* De Selys-Longchamps in Monog. 30, *F. u. F. d. Golfes v. Neapel*, 1907.

[5] *Cf.* M'Intosh, *7th F. B. Rpt.*, pt. iii. p. 285.

POLYZOA OR BRYOZOA.

In 1862 Dr M'Bain gave a short list of Marine Polyzoa from the Firth of Forth, in the first edition of Wood's *East Neuk of Fife,* and they were further investigated by Charles W. Peach, who furnished Leslie and Herdman with many good records for this section of their "Invertebrate Fauna" of the Firth. Some earlier records by Coldstream, Grant, Landsborough, and others are cited in the works of Johnston and Hincks.[1] From these sources, supplemented by their own investigations, the authors of the "Fauna" were able to present a list of 61 species. To this Henderson (*l.c.*) added 6,[2] and among Pearcey's records I find other 3 additions,[3] making 70 in all. One would expect a good many more than this to occur in the Forth—say 80 to 90—seeing over 100 are enumerated from the Firth of Clyde.

The following fresh-water Polyzoa were recorded from the neighbourhood of Edinburgh by Sir J. G. Dalyell and Professor G. J. Allman, and doubtless two or three others will yet be found. The records are for the most part taken from Allman's *Monograph of the Fresh-Water Polyzoa,* published by the Ray Society in 1856.

Cristatella mucedo, Cuv. (= *C. mirabilis*, Dll.[4])—Duddingston Loch, and pond at Binns House, Linlithgowshire (J. G. D.); Union Canal, Edinburgh (G. J. A.).

Plumatella repens (L.)—Blackhall Pond, and old quarry at Fenton Tower, Haddingtonshire (J. G. D. in *Rare and Rem. Anim.*); pond near Davidson's Mains (W. E.).

Fredericella sultana (Blum.)—Union Canal (G. J. A.); and more recently, 1888 (W. E.).

Paludicella ehrenbergi, v. Ben.—Union Canal (G. J. A.).

Dalyell's *Alcyonella stagnorum*, from a pond in Heriot Row, Edinburgh, was, according to Allman (*op. cit.*, p. 71) probably a young condition of *Plumatella.*

[1] Johnston's *Brit. Zoophytes*, 2nd ed., 1847; Hincks' *Brit. Mar. Polyzoa* (1880). In *Ann. Nat. Hist.* for 1852, Wyville Thomson recorded *Avenella fusca*, Dll.

[2] *Bugula flabellata*, J. V. Thomp., *Membranipora dumerilii*, Aud., *Cribrilina annulata*, Fab., *Porella concinna*, Busk, *Cellepora dichotoma*, Hincks, and *Diastopora obelia*, Flem.

[3] *Cellaria sinuosa*, Hass., *Flustra papyracea*, E. and S., and *Membranipora hexagona*, Busk.

[4] *Rep. Brit. Assoc.*, 1834, p. 598; and *Rare and Remarkable Animals of Scotland*, ii., 1848.

MOLLUSCA.

The Mollusca, or rather their shells, have long been a subject of interest to Forth naturalists, marine and non-marine species alike having been noted and recorded. They early received some share of attention from Sibbald (*l.c.*), Laskey, Neill, Fleming, Greville, Forbes, M'Bain, and others, and they have been extensively collected ever since. Captain J. Laskey collected largely on the Haddingtonshire coast, but his long list, published in the *Wernerian Memoirs* for 1809 (vol. i.), is unfortunately marred by the inclusion of many spurious species and other doubtful records.[1] Useful lists of land and fresh-water species were given in Rhind's *Excursions* in the environs of Edinburgh (1833 and 1836 editions), in Stark's *Picture of Edinburgh* (1834), and by Dr Greville in the New Statistical Account of the Parish of Dalmeny (1843). The longest is that in the 1836 edition of Rhind's little book, where 64 species (about 60 according to present views) are recorded, with localities, many of them communicated by Captain Brown and E. Forbes. Stark's list, contributed I believe by Dr Neill, includes some marine species as well. Naturally, a good many local records are to be found in Forbes & Hanley's *History of British Mollusca* (1853), and also in Jeffreys' *British Conchology* (1862-1869). In 1862 a valuable list of Mollusca (177 species) inhabiting the Firth of Forth and a portion of Fifeshire, furnished by Dr James M'Bain, was published in Wood's *East Neuk of Fife.* To the German Expedition of 1872, we owe a few first records for the Forth.

This brings us to Leslie & Herdman's indispensable Catalogue of the Marine Mollusca of the Area, published in 1881 in their "Invertebrate Fauna." As the result of their own investigations, combined with the previously published records (Laskey's excepted), and supplemented by others obtained from the collection in the Edinburgh

[1] The list, which is entitled, "Account of North British Testacea," contains considerably over 200 "species" of Mollusca from Forth. Ballast shells—a number of them exotic species—from Dunbar are probably accountable for not a few of the records (see comments in the works of Forbes and Hanley, and Gwyn Jeffreys; also notice of Laskey by R. Gray in *Proc. Berw. Nat. Club*, viii. p. 73).

Museum, from the late F. M. Balfour, F.R.S., and in particular from the Rev. Dr J. M'Murtrie, they were able to give a substantial list of 201 species and numerous varieties. For subsequent records we are indebted mainly to Dr Henderson and the Fishery Board naturalists—Dr Scott and Mr Pearcey. Their additions, together with a few others I have met with, are given below. These number 42,[1] and raise the total of the marine section to 243, a figure which, though small as compared with the Clyde list say, is not likely, I consider, to be augmented by more than 30 to 40 at most. Two of Dr Scott's discoveries, namely, the Pteropods *Clione limacina*, Phipps (*Clio borealis*, Brug.), and *Limacina retroversa* (Flem.), are especially interesting. The paucity of records of *Teredo* is perhaps also worthy of remark. Of living Brachiopods there appears to be none in Forth.

To return to the land and fresh-water section, it has been very thoroughly worked up afresh in connection with Mr W. D. Roebuck's "Census" of the Scottish species, published in the *Proceedings* of this Society in 1890, and supplemented in the *Annals of Scottish Natural History* in subsequent years. The "Census," it should be explained, takes cognisance only of specimens examined and authenticated by a committee of the Conchological Society, all other records being rigidly excluded. Of the many book-records thus purposely omitted, notice need be taken here only of those relating to *Cœcilioides acicula* (Müll.) from this district, published in vol. i. of our *Proceedings* (pp. 346 and 398). My own interest in the non-marine section began many years ago, and, though at its height during the preparation of the Census, still continues. But, as may be seen by reference to that paper (including the supplements) and other channels of publication, I have been by no means the only worker in this field. Mr Roebuck himself visited the district, chiefly in search of slugs, and the following have rendered signal service in forwarding specimens for authentication, namely—Mrs Carphin, Rev. Dr M'Murtrie, Dr Scott, Messrs R. Godfrey, A. M'Lellan (Stirling district), and G. M'Dougall (Bridge of Allan district). In order to bring together all this scattered information, I have in preparation

[1] Several, however, are probably not native to the Firth, now at any rate.

a fully annotated Catalogue of the Land and Fresh-Water Mollusca of the area, which would probably have been completed ere this but for the unsettled state of the nomenclature, and my desire to follow in this matter Mr J. Taylor's grand monograph of the British species, now in course of publication. My list contains 96 species, exclusive of *Neritina fluviatilis* and *Paludina vivipara,* which occur only as ballast shells, and one or two doubtful records in Captain Brown's "Illustrations" (1845), and some other works.

There are thus in all 339 species (with numerous varieties) of Mollusca at present reported from "Forth." What work there is still to do lies mainly among the marine forms, a revised list of which is needed if only to incorporate the records of the past twenty-five years, and modernise the nomenclature. More observations, however, on many points are required before a really satisfactory catalogue can be drawn up. The Nudibranchs and Cephalopods, for instance, want further investigating.[1] From my own gleanings on the sands of the Forth could be given additional records of a number of our rarer shells.

The subjoined is a list of recorded additions to Leslie and Herdman's catalogue of the marine species. The names are practically all left as they were published, but I have ventured to place one or two in square brackets for the present: there is always the possibility of "ballast" and post-glacial shells to take into account. H. = Henderson, P. = Pearcey, and S. = Scott.[2]

[1] In dealing with the records of Cephalopoda in L. & H.'s list, the following should also be consulted:—*Loligo forbesii*, Stp. (the so-called *L. vulgaris* of our coasts), see Dr Hoyle's note in our *Proceedings*, viii. p. 459, and *cf.* also Canon Norman's "Revision of Brit. Mollusca," *Ann. and Mag. N. H.* (6), v.; *Moschites* (*Eledone*) *cirrosa*, T. Scott, *Ann. S. N. H.*, 1893, p. 50, and paper by me in same magazine for 1899, p. 6, on the destruction of animal life in the Firth of Forth by the gale of Oct. 1898; *Rossia macrosoma*, W. Evans, *ib.; Sepiola rondeleti*, R. Godfrey, *A. S. N. H.*, 1900, p. 125. Pearcey's record of *Octopus vulgaris* (*l.c.*, p. 238), if correct, is noteworthy; but probably *Moschites* is meant.

[2] Henderson's records are in his two papers in *Proc. Roy. Phys. Soc.*, viii.; Pearcey's in *Trans. N. H. Soc. Glasg.*, n.s., vi.; Scott's in *Fishery Board Reports* (7*th*, 8*th*, 9*th*, 12*th*, and 16*th*) except when otherwise stated. Further records for many of the species in L. & H.'s list are also contained in the papers of Scott and Pearcey.

[*Mytilus barbatus*, L., dead (P.)]; *Pecten striatus* (Müll.) (H., P.); *Lima loscombi*, G. B. Sow. (H.); *Astarte sulcata* v. *scotica*, M. & R. (H.); [*Isocardia cor* (L.); Laskey says he took one alive in the Firth near St Abb's Head, *Wern. Mem.*, i. p. 385]; *Loripes lacteus* (L.) (P.); *Diplodonta rotundata* (Mont.) (S., P.); *Lepton nitidum*, Turt. (S.); *Scrobicularia tenuis* (Mont.) (P.); *Tellina crassa* v. *albida*, Jeff. (H.); *Tellina pusilla*, Phil. (H., P.); [*Venus verrucosa*, L., young (P.). A large one is said by Laskey to have been dredged at Dunbar)]; *Circe minima* (Mont.) (S.); *Cardium nodosum*, Turt. (S., P.); *Xylophaga dorsalis* (Turt.) (S., *Ann. S. N. H.*, 1896, p. 63); *Teredo* sp., in the wood of Leith west pier (S. Macadam, *Proc. R. Ph. S. Edin.*, iii. p. 235), and borings numerous and large in block of wood on beach west of Aberdour, Oct. 1903 (W. Evans); *Lyonsia norvegica* (Chemn.) (H., S.); *Dentalium tarentinum*, Lmk. (P.); [*Trochus umbilicatus*, Mont. (P., who also records *T. magus*, L., of which Leslie & Herdman mention only a worn shell)]; *T. montagui*, W. Wood (S.); *T. zizyphinus* v. *lyonsi*, Leach (S.); *Rissoa violacea*, Desm. (P.); *R. proxima*, Ald. (P.); [*R. cancellata*, da C. (Brown, in Jeffreys' *Brit. Conch.*, iv. p. 10)]; *Natica montagui*, Forbes (H., P.); *Scalaria trevelyana*, Leach (Gerard in *Brit. Conch.*, iv. p. 94, H.); *Odostomia albella*, Lov. (P.); *O. insculpta*, Mont. (P.); *O. rufa* v. *fulvo-cincta* (Thomps.) (H., S., *A. S. N. H.*, 1893, p. 184); *Eulima polita* (L.) (S., P.); *E. intermedia* (L.) (P.); *Stilifer turtoni*, Brod. = *S. stylifer* (Turt.) (Miss Carphin *vide* S., *Proc. R. Ph. S.*, x. 156); *Trichotropis borealis*, Brod. & Sow. (H.); *Trophon muricatus* (Mont.) (P.); *T. m.* v. *barvicensis*, Johnst. (H.); [*Pleurotoma striolata*, Sca. (P.)]; *Cylichna nitidula*, Lov. (S.); *Utriculus mammillatus*, Phil. (P., also Brown *fide* Jeffreys, iv. 420); *Philine scabra* (Müll.) (H., P.); *Limacina* (*Spiralis*) *retroversa* (Flem.) (S., *vide* 7*th F. B. R.*, pt. iii. p. 325, and 16*th*, p. 155); *Clione* (*Clio*) *borealis* (Brug.) = *Clione papilionacea*, Pall., now *Clione limacina*, Phipps (S., *Proc. R. Ph. S. E.*, x. 156, 7*th F. B. R.*, pt. iii. 325; *cf.* also 12*th*, p. 92, and 16*th*, p. 155); *Alderia modesta*, Lov. (S.); *Limapontia nigra*, Johnst. (S.); *Eolis viridis*, Forbes (P.); *E. ventilabrum*, Dll. (*Powers of the Creator*, ii. p. 318)[1]; *Polycera lessoni* (d'Orb.) v. *ocellata*, Ald. & Han. (P.); *Sepia officinalis*, L. (one, 4 miles south of May Island (P.); *cf.* also Stark's *Picture of Edinburgh*, p. 326).

This review of our knowledge of the Molluscan fauna of Forth would be incomplete without a reference to the researches of Hugh Miller, Rev. T. Brown, R. Etheridge, Jun., J. Bennie, and others, on the Post-Tertiary deposits in the neighbourhood of Edinburgh, Elie, etc.[2]

[1] This = *Embletonia pulchra*, Alder & Hancock—see their *Nudibranchiate Mollusca*, pt. vii. (1855), Appendix, p. xiii.

[2] *Cf.* papers in our *Proceedings*, vols. vi., x., xi.; etc.

ARACHNIDA.

But for a few Spiders recorded by the Rev. O. P. Cambridge in 1862,[1] this difficult and unpopular class was practically untouched in Forth till I took it up about eighteen years ago. Attention was first given to the order Araneidea or Spiders, next to the Phalangidea or Harvestmen, then to the Chernetidea or False-scorpions, and lastly to the Acarina or Mites and Ticks. For convenience these may best be considered separately.

ARANEÆ (ARANEIDEA).—In the working out of my numerous collections of Spiders, I was fortunate in securing the co-operation of my friend Prof. G. H. Carpenter of Dublin, who was then studying the group in Ireland. Many of the specimens were also examined for us by the Rev. O. P. Cambridge, F.R.S. The results of several years' investigations around Edinburgh were given in a joint paper by Mr Carpenter and myself, which was published by this Society in 1894; and three supplements have followed, the last in 1904.[2] The species recorded in these papers number 204. In 1897 we published in the *Annals of Scottish Natural History* a list of the species obtained by me in the Upper Forth district—which in this instance has been treated separately; and in the same magazine for 1905 I reported several additions thereto.[3] The number recorded from "Upper Forth" is 134 of which 13 are not in the Edinburgh list. Adding two or three taken many years ago near Cockburnspath by the late Dr James Hardy,[4] we have in all 220 Araneæ at present known from the Forth area, out of a probable 250 or thereabout. Records of some interesting mountain species may be expected when the higher hills beyond Callander have been more fully searched. Near the summit of Am Binnein, in September 1902, I found *Tmeticus montigena* (L. Koch) fairly

[1] "Sketch of an Arachnological Tour in Scotland in 1861," *Zoologist*, p. 8041 (1862). *Cf.* also *Entomologist* for 1877.

[2] "Spiders (Araneidea) collected in the Neighbourhood of Edinburgh," *Proc. Roy. Phys. Soc. Edin.*, xii. pp. 527-590; *ib.*, xiii. pp. 308-315; xiv. pp. 168-178; and xvi. pp. 27-34.

[3] "List of Spiders collected in 'Upper Forth,'" *Ann. Scot. Nat. Hist.*, 1897, pp. 226-236; and additions, *ib.*, 1905, p. 120.

[4] *Trans. Berw. Nat. Club*, vol. vii.

common. My collections of Scottish spiders have furnished Mr Cambridge with the types of nine new species,[1] besides many other additions to the British list.

PHALANGIDEA.—The results as regards this order have also been published in joint papers by Professor Carpenter and myself communicated to this Society in 1895 and 1899.[2] The number of species recorded is 16, which probably comes very near being a complete list for the area. *Oligolophus hansenii* (Kraep.) was undescribed when I first found it.

CHERNETIDEA.—In the two papers referred to under the previous order, a few False-scorpions were also recorded, and in subsequent notes in the *Ann. Scot. Nat. Hist.*[3] I have mentioned the occurrence of several others. Mr R. Godfrey, who has recently paid much attention to this order in Scotland, has published notes on 5 species occurring in West Lothian,[4] the county in which he first found the interesting *Chernes dubius*, Cambr. So far only 8 species, as under, have been detected by us in Forth, where it is not too much to expect at least a dozen to occur. A score or so have been taken in Britain.

Chthonius rayi, L. K.—Not uncommon; Fife and the Lothians; Abbey Craig, near Stirling, April 1906.

C. orthodactylus (Leach)—Rare; Morningside, Edinburgh, one in garden, Sept. 1897.[5]

C. tetrachelatus (Preys.)—Wide-spread and fairly common; Lothians and Fife.

Obisium muscorum, Leach—By far our commonest species, and generally distributed, occurring from sea-level to the tops of the highest hills—I have it, for example, from the Isle of May, and the summits of East Cairn-hill (Pentlands), Ben Ledi, and

[1] These are:—*Dictyna arenicola*, Luffness Links and Loch Morlich; *Tmeticus carpenteri*, Pentland Hills; *Sintula fausta*, Lauder; *S. nescia*, Comrie; *Gongylidium morum*, Aberlady; *G. gibbum*, Comrie; *Cnephalocotes ambiguus*, Arran (not Bute); *Caledonia evansii*, Pentland and Lowther Hills; *Evansia merens*, Glenfarg. For descriptions *cf. Proc. Dors. Field Club*, etc.

[2] "Phalangidea (Harvestmen) and Chernetidea (False-scorpions) collected in the Neighbourhood of Edinburgh," *Proceedings*, xiii. pp. 114-123; and additions, *ib.*, xiv. pp. 178-181.

[3] 1901, pp. 53, 241; 1903, pp. 120, 249; 1905, p. 247; and 1906, p. 57.

[4] *Ann. Scot. Nat. Hist.*, 1901, p. 214. *Cf.* also *id. ib.*, 1908.

[5] Of the specimens recorded by Carpenter and myself (*l.c.*) as *C. orthodactylus*, that from my garden in 1897 seems right, but an Aberlady one—the only other preserved—is evidently an immature *C. tetrachelatus.*

Stuc-a-Chroin (3189 feet). Writing in 1817, Leach says of it, "In montibus Caledoniæ vulgatissime."[1]

Chelifer latreillii, Leach—Common on coast of East Lothian and Fife; was first recorded from our area by H. Crowther.[2]

Chernes dubius, Cambr.—Not uncommon locally; West and East Lothian, and Fife.

C. nodosus (Schr.)—Apparently rare; Edinburgh, twice on legs of flies.

Chiridium museorum (Leach)—Locally common in buildings, Lothians and Fife.

Acarina.—In this, the most neglected and difficult order of the Arachnids, I made a beginning three or four years ago, and have now a list of about 185 species nearly ready for publication. With Michael's *British Oribatidæ* and his treatise in *Das Tierreich* as text-books, and the invaluable help of Messrs Warburton and Pearce of Cambridge, the Oribatids, or beetle-like mites, have received most attention. Eighty species, several of them new or only lately discovered,[3] have been secured. As this represents 73 per cent. of the British list, I do not expect to obtain many more in this family. Lichen, moss, etc., from the sea-cliffs in the east to the hill-tops in the west, have been examined, and the results seem to show that, given the proper kind of nidus, the majority of these minute animals are little affected by altitude. In September last, a bundle of moss from a wood below Callander yielded 33 species, against 24 yielded by a similar quantity from the summits of Ben Ledi and Stuc-a-Chroin.

Next to the Oribatidæ, the beautiful Hydrachnidæ or Water-mites, of which a few were known to Johnston and Dalyell,[4] have claimed my attention. My list, so far, runs to over 50 species, but the family is a difficult one to work. No English monograph of the group has yet been published, and it is a fact that neither of the two indispensable German works by Piersig is in any of the Edinburgh libraries. The Hydrachnids of Scotland as a whole, are receiving attention from Mr W. Williamson, who has recently published, in *Trans. Edin. Field Nat. Soc.*, the names of 30 species he has met with, but he does not say which of them were taken in this

[1] *Zoological Miscellany*, iii. (1817), p. 48.

[2] *Science Gossip*, xviii. (1882), p. 277; and *Zoologist*, 1882, p. 465.

[3] With one exception they are described by Warburton and Pearce in *Proc. Zool. Soc.*, 1905, vol. ii.

[4] *Hist. Berw. N. C.*, vol. ii., and *Powers of the Creator*, vol. i.

district. Some of his Forth captures, however, were recorded by Mr Soar a few years ago.[1] Among mine there are a number of additions to the Scottish list.[2]

Of the marine Mites (Halacaridæ) I have as yet obtained but two, namely, *Rhombognathus seahami* (Hodge), from North Berwick and Dunbar, and a *Halacarus* from the latter place. Three or four species of Ixodidæ (Ticks) have been identified,[3] and a fair number of Trombidiidæ, Gamasidæ, Eriophyidæ, etc.

In all 430 Arachnids are known to me from "Forth," and I should say a list of 550 is not too much to look forward to.

LINGUATULIDA (Pentastomida).

A specimen of *Linguatula* (*Pentastoma*) *tænioides*, Rud., from the nostril of a dog in Edinburgh, 1907, has been shown to me by Dr J. H. Ashworth.

TARDIGRADA.

This perplexing group of microscopic animals, to which the fanciful name of Water-bears has long been applied, has, until quite recently, received little attention in this country.[4] Three or four years ago Mr James Murray took

[1] *Trans. Edin. Field Nat. Soc.*, 1903, v. p. 40. Williamson's list, and a later one, are in same vol., pp. 239 and 393.

[2] My Forth list includes the following species:—*Eulais infundibulifera*, Koen., var. *stagnalis*, Halb.; *E hamata*, Koen.; *Hydrachna globosa* (De G.); *Diplodontus despiciens* (Müll.); *Panisus michaeli*, Koen.; *Hydryphantes frici*, Thon; *H. plicationis*, Thon; *Arrhenurus globator*, Müll.; *A. forpicatus*, Neum.; *A. ornatus*, George; *Aturus scaber*, Kram.; *Midea orbiculata* (Müll.); *Torrenticola anomala* (Koch); *Mideopsis orbicularis* (Müll.); *M. crassipes*, Soar; *Brachypoda versicolor* (Müll.); *Lebertia porosa*, Thor.; *Frontipoda musculus* (Müll.); *Teutonia primaria*, Koen.; *Sperchon brevirostris*, Koen.; *S. glandulosus*, Koen.; *S. denticulatus*, Koen.; *S. squamosus*, Kram.; *Limnesia undulata* (Müll.); *Atractides spinipes*, Koch; *Hygrobates trigonicus*, Koen.; *H. reticulatus* (Kram.); *Hydrochoreutes ungulatus* (Koch); *Laminipes ornatus* (Koch); *Tiphys cassidiformis* (Haller); *T. liliaceus* (Müll.); *Piona longipalpis* (Krend.); *P. rotunda* (Kram.); *P. rotundoides*, Thor.; *P. discrepans* (Koen.); etc. I ought to say that Messrs Halbert and Soar have kindly helped me with the identifications.

[3] Evans, W., "Some Scottish Ixodidæ (Ticks)," *Ann. Scot. Nat. Hist.*, 1907, pp. 34-37. A few other Acarina have been recorded by me in the *Annals*.

[4] Under the name of "Urslet," a Tardigrade was recorded from Scotland (no locality given) nearly a hundred years ago, *Edin. Encycl.*, ii. (1811), p. 143.

up the study of the group, and already it has been the subject of several important papers by him.[1] As a result of the examination of material collected by me in this district during the last two years, he has published two papers in the *Annals of Scottish Natural History*[2] on "The Tardigrada of the Forth Valley." The number of species there recorded is 16, three of them—*Diphascon scoticum*, *D. bullatum*, and D. *oculatum*—being named and described as new to science. Two other forms, possibly also new, are described, but not named. Since these papers were written Mr Murray has detected another species, *Macrobiotus papillifer*, Mur., in moss I brought from the top of Ben Ledi on 4th September 1906, so that we now know of 17 named forms, regarded as specifically distinct, from the area.[3]

It is quite impossible to say what number of Water-bears may be expected to occur in "Forth," so many unknown quantities having to be reckoned with, but, according to our present knowledge, 25 to 30 does not seem an extravagant estimate. Mr Murray tells me his list for Scotland, as a whole, now amounts to about 40 species.

PYCNOGONIDA.

This small, but none the less remarkable class of marine Arthropods, frequently called "Sea-spiders,"—a vernacular name which Mr Stebbing suggests might with advantage be replaced by "Sea-spindles"[4]—has never been properly worked in Forth waters. In 1842 Harry Goodsir described *inter alia* three from the Firth of Forth, namely, *Pallene*

[1] "The Tardigrada of the Scottish Lochs," 1905, and other papers in *Trans. Roy. Soc. Edin.*, etc.

[2] 1905, pp. 160-164; and 1906, pp. 214-217. In the *Zoologist* for 1907, p. 3, Murray describes *Macrobiotus dispar*, n.sp., previously recorded from ponds near Edinburgh as *M. mucronyx*, Doy. Another locality, from which I obtained it in August 1906, is Camilla Loch, Fife.

[3] In his latest paper on Scottish Tardigrada (*Trans. R. S. E.*, xlv., p. 663, 1907), Murray describes another new species, *Macr. pullari*, from the Forth area, etc. Perhaps it is the form he referred to *M. ornatus*, Richt., in his Forth list.

[4] "The No-bodies—a sea-faring family," is the title of a series of instructive chapters on the Pycnogonida by the Rev. T. R. R. Stebbing, in *Knowledge* for 1902 and 1903.

circularis, Nymphon pellucidum, and *N. minutum*;[1] but several of his species, among them these two Nymphons, are, to quote Stebbing, "foundlings which still utter feeble but unanswered cries for recognition."

Leslie and Herdman, in their catalogue of Forth Marine Invertebrata, 1881, gave only two species, *Pycnogonum littorale*, Müll., and *Nymphon gracile*, Leach, but it is questionable if the latter name was correctly applied. In 1884 Dr Henderson (*l.c.*) reported three additions, namely, *Nymphon hirtum*, Kröy., *N. brevirostre*, Hodge, and *N. grossipes*, O. Fab., and considered he had other two species unidentified. In a catalogue of the Crustacea and Pycnogonida in the Museum of University College, Dundee, dated 1901, which Professor D'Arcy Thompson has kindly sent me, the following are entered from the Firth of Forth:—*Nymphon rubrum*, Hodge, *Chætonymphon hirtum* (Fabr.), *Pallene brevirostris* (Johnst.), and *Anoplodactylus petiolatus* (Kr.).[2] In 1902, Pearcey (*l.c.*) recorded *Nymphon gallicum*, Hoek, which is the same as *N. gracile*, Leach. When shore-collecting I have occasionally found a few Pycnogonids, but have seldom troubled to preserve them. Those I have kept were got under stones between tide-marks, at North Berwick, in January 1896, and belong to two species, the common *Pycnogonum littorale*, Ström. (several, one with large cluster of ova attached), and *Phoxichilidium femoratum* (Rathke), ♂ and ♀.[3] The last-named does not appear to have been previously recorded from the Firth, and brings the number of species known from its waters up to ten.

The number of British Pycnogonida is uncertain. According to Stebbing, "we can with some assurance boast of ten genera, and twice that number of species," but a higher figure has been named. Surely the Firth of Forth ought to be able to produce at least a dozen "no-bodies" if properly pressed to yield up its treasures.

Note.—Since the above was written, the Rev. Canon A. M. Norman has published a valuable paper on "The Podosomata

[1] "Descriptions of some New Species of Pycnogonidæ," *Edin. New. Phil. Jour.*, xxxii. (1842), pp. 136-139.

[2] Professor D'Arcy Thompson tells me they now have also *N. brevirostre*, Hodge, and *Pycn. littorale*, Ström., from the Firth.

[3] See my note in *Ann. Scot. Nat. Hist.*, 1907, p. 119.

(= Pycnogonida) of the Temperate Atlantic and Arctic Oceans,"[1] in which 32 species—a number of them abyssal forms—are recorded for the "British Area." Adopting the nomenclature and synonymy of this Catalogue our Forth list stands thus:—

Phoxichilidium femoratum (Rathke).
Anaphia petiolata (Kröy.).
Pallene brevirostris, Johnst.
Phoxichilus circularis (Goodsir).
Nymphon rubrum, Hodge (*N. gracile*, Johnst. *nec* Leach).
N. brevirostre, Hodge (*N. gracile*, Sars).
N. grossipes, Fabricius.
N. gracile, Leach (*N. gallicum*, Hoek).
Chætonymphon hirtum (O. Fab.) (*N. spinosum*, Goods., *nec* Sars).
Pycnogonum littorale, Ström.

CRUSTACEA.

Of this important section of the Arthropoda our knowledge is very full and up to date, thanks mainly to the industry and skill of Thomas Scott, LL.D., F.L.S., who has for many years made the subject his own. Dr Scott's "Catalogue of Land, Fresh-Water, and Marine Crustacea found in the Basin of the River Forth and its Estuary," recently laid before this Society,[2] is a valuable piece of work, and the author is to be congratulated on its completion. It includes in all no less than 796 species. In course of time further discoveries will no doubt be made, but there seems little reason to suppose that the number of Forth Crustacea can exceed 850 or thereby.

In his capacity of naturalist to the Fishery Board for Scotland, Dr Scott has had, during the past twenty years, unrivalled opportunities for investigating the Crustacean fauna of the area, and he has certainly made full use of them. The foundations of the Catalogue were, of course, laid long before Dr Scott's investigations began, by Sibbald, Jameson, Leach, H. Goodsir,[3] J. Anderson, Howden, M'Bain, and others, but their observations were practically confined to the larger forms, *i.e.*, to the Malacostraca and Cirripedia. A good many species were added to the list from the mouth

[1] *Journ. Linn. Soc.*, *Zool.*, xxx., p. 198 (1908).

[2] *Proceedings*, xvi. pp. 97-190, and pp. 267-386 (1906). Dr Scott's records originally appeared in numerous papers in the Reports of the Fishery Board for Scotland, the *Proceedings* of our Society, and the *Annals Scot. Nat. Hist.*

[3] "Description of some new Crustaceous Animals found in the Firth of Forth," *Edin. New. Phil. Journ.*, xxxiii. (1842), p. 365; etc.

of the Firth, by the German North Sea Expedition of 1872 (*cf.* Metzger's Report on the Crustacea). A few Entomostraca from the coast between Dunbar and Cockburnspath were recorded by Baird as early as 1835-1838,[1] and some attention was given to the Ostracoda—a subdivision thereof—by Brady and Robertson in the "sixties." Leslie and Herdman did not attempt to treat of the Entomostraca, and give in their Catalogue (1881) only the Malacostraca and Cirripedia—a list of 96 species, to which Henderson (1884) added 20.

The great subclass Entomostraca—at any rate the Cladocera and Copepoda—were up to this time almost untouched, and it is chiefly among these microscopic forms that Dr Scott has laboured with such marked success. A valuable paper on the fresh-water Crustacea (nearly all Entomostraca, of course) of Midlothian, by Dr and Miss Sprague, was published in the *Transactions* (vol. iv.) *of the Edinburgh Field Naturalists' and Microscopical Society* in 1901.[2] The terrestrial Isopods are practically the only group to which I have myself paid attention.[3] Such of my records of these and other Crustacea as are of any interest have been given to Dr Scott. During the present year I have sent him gatherings of Entomostraca from some localities in the area which he had not himself visited, including Loch-a-Chroin (2500 feet above sea-level), and a spring at nearly the same elevation on Ben Ledi.[4]

[1] *Trans. Berw. Nat. Club*, i. p. 95; and *Mag. Zool. and Bot.*, i. and ii. (1837-38). In 1863 W. Turner and H. S. Wilson recorded *Lerneopoda* (*Charopinus*) *dalmanni* (Retz.), from Skate caught by Newhaven fishermen (*Trans. Roy. Soc. Edin.*, xxiii. p. 77).

[2] An early record from Duddingston Loch is that of "*Cypris reniformis*, Daudebart de Férussac, fils," by Leach, in *Edin. Encycl.*, vii., 1813, p. 388. In D. Robertson's "Fresh and Brackish-water Ostracoda," *Fauna of Scotland*, etc., Glasgow, 1880, there are a number of records from lochs about Edinburgh.

[3] See records of *Platyarthrus hoffmanseggii*, etc., in *Ann. Scot. Nat. Hist.*, 1900, p. 186; 1901, p. 120; and 1906, p. 187.

[4] The following species, identified by Dr Scott, occurred in these two gatherings, namely—(1) Loch-a-Chroin, 17th September 1906, *Bosmina longirostris* (O. F. Müll.), *Acroperus harpæ*, Baird, *Alonopsis elongata*, G. O. Sars, *Alona quadrangularis* (O. F. M.), *Alonella excisa* (Fisch), *Chydorus sphæricus* (O. F. M.), *Cyclocypris serena* (Koch), *Diaptomus gracilis*, G. O. Sars, *Cyclops viridis* (Jur.), *C. serrulatus*, Fisch.; also *Gammarus pulex* (De G.). (2) Ben Ledi, 4th September, *Chydorus sphæricus* (O. F. M.), *Erpetocypris tumefacta* (B. and R.), *Cypridopsis villosa* (Jur.), *Potamocypris fulva* (Brady), *Candona candida* (O. F. M.), *Attheyella zschokkei* (Schm.), *A. cuspidata* (Schm.), *Cyclops vernalis*, Fisch. In peat-pools on Bavelaw Moss, 29th May 1908, I obtained *Acantholeberis curvirostris* (Müll.), *Cyclops languidus*, Sars, and *C. nanus*, Sars, for each of which only one locality is given in Scott's Catalogue: determined by Mr Scourfield.

For a fuller account of the history of this section of our Fauna, I would refer you to the introductory part of Dr Scott's Catalogue.

MYRIAPODA.[1]

(Centipedes and Millipedes.)

A few Centipedes and Millipedes were recorded from the neighbourhood of Edinburgh by C. Stewart in his 1809 list of "Insects," and by Dr W. E. Leach, of the British Museum, in his papers on Crustaceology, etc., a few years later, 1813-1815 (Brewster's *Edin. Encycl.*, and *Trans. Linn. Soc.*). The types of Leach's *Craspedosoma rawlinsii* were got near the city, where it still occurs. A short list of eleven "Insecta Myriapoda found in Berwickshire," by Dr G. Johnston, appeared in 1835 in Loudon's *Magazine of Natural History*, but no precise localities are given, and we cannot tell what species, if any, were known to him from the corner of the county falling into "Forth." In 1882 Sir T. D. Gibson-Carmichael contributed to the *Proceedings of the Royal Physical Society* a preliminary list of Scottish Myriapoda, in which seven have Forth localities assigned to them. In recent years I have myself given considerable attention to the group, with the object of supplying a list for the Forth area. My paper on the subject was laid before this Society towards the close of last session, and is being published in the *Proceedings*.[2] Exclusive of a few aliens, it deals with 33 species, 16 belonging to the class Chilopoda (Centipedes), 1 (*Scolopendrella immaculata*) to Symphyla, and 16 to Diplopoda (Millipedes), and shows their distribution in considerable detail.

About fifty species are, I believe, known to Mr R. I. Pocock to occur in the British Islands, but a number of them are probably confined to the south of England, finding there the more genial climate they require. Nevertheless, I feel sure there are still a few here to reward further investiga-

[1] For convenience I here retain the term Myriapoda, but merely as a collective name, and not as a "class" of which it embraces several.

[2] "The Myriapods (Centipedes and Millipedes) of the Forth Area," *Proc. Roy. Phys. Soc. Edin.*, xvi. pp. 405-414, and xvii. pp. 109-120. I had previously, in *Ann. Scot. Nat. Hist.* for 1900 and 1901, recorded several additions to the Scottish list from Forth.

tion. Many species are superficially so very similar that there is always a likelihood of some being overlooked; indeed, the proper determination of Myriapods is a matter of no little difficulty, and a book on those to be found in this country is greatly needed.

INSECTA.

In the Insecta we have to deal with an enormous class, containing as it does more species than all our other groups put together. Of the nine orders into which it is usually divided, only the two popular ones—the Coleoptera (beetles) and the Lepidoptera (butterflies and moths)—had up to a few years ago received serious attention. The first published list of insects from the district was, however, a general one. It was drawn up by Charles Stewart, and communicated to the Wernerian Natural History Society in 1809.[1] Excluding a few arachnids, crustaceans, and myriapods, it contains the names of 369 species, of which 108 are Coleoptera, 97 Lepidoptera, and 66 Diptera (flies), the remaining 98 being distributed among the other orders. Passing over some scattered records in the works of Leach and Stephens, we come to (Rev.) James Duncan's valuable "Catalogue of Coleopterous Insects found in the Neighbourhood of Edinburgh," submitted to the Wernerian Society in 1831,[3] in which 543 species—a number of them on the authority of Sir Patrick Walker, James Wilson (of Woodville), and other entomologists—are

[1] *Memoirs*, i. (1811) pp. 566-577.

[2] In this connection the following extract from the *Scots Magazine* for Oct. 1811 (p. 727) is interesting:—"The study of entomology, we are happy to find, is now gaining ground, not only in the Scottish metropolis, but in different parts of the country. Five or six keen naturalists have recently entered on the pursuit, and laid the foundation of as many cabinets. The excitement of a taste for this department of natural science, is in a great measure to be ascribed to the temporary residence in Edinburgh, of a member of the Linnean Society—W. E. Leach, Esq.—distinguished for his entomological knowledge, and as possessing one of the richest cabinets of British insects. This gentleman has, in the most liberal manner, admitted all cultivators of Scottish natural history in general, to inspect and consult his extensive and admirable collection" (Neill).

[3] *Memoirs*, vi. (1832) pp. 443-538. At p. 580 it is mentioned that "this communication gave much pleasure to the Society, as affording an earnest of the revival of the study of entomology in this place, where it had been much neglected for a good many years past."

recorded with localities. About this time Wilson and Duncan conceived the idea of a complete *Entomologia Edinensis,* but only the well-known volume on the Coleoptera, published in 1834, in which are enumerated and described 634 species, ever appeared. Some 60 additions to this list were recorded by Dr R. K. Greville in the *Magazine of Zoology and Botany* for 1837.[1] Diptera were now engaging the attention of Duncan, in whose papers on the British species in the same magazine (vols. i. and ii.) a number of records from this district are given.[2] To James Hardy, LL.D., we owe many early records of Coleoptera and other insects from the neighbourhood of Cockburnspath,[3] and the New Statistical Account of the parish of Dollar (1841) contains an interesting list of beetles for that locality. About this time, too, those minute Hymenoptera, the Chalcids, as we shall see later, were being collected by Dr Greville.

Our next entomological landmark is "The Lepidopterous Insects of Midlothian"—an annotated list of 485 species, of which 267 are "macros" and 218 "micros"—by Dr W. H. Lowe and R. F. Logan, printed in *The Naturalist* for 1852 (pp. 121-131), with 50 additions in 1853 (p. 69). Investigations in this order were continued for some years by an entomological committee of this Society, with which the name of Andrew Wilson is intimately associated.[4] Beetles were now being collected in more districts than formerly, and the knowledge of their distribution in the area was greatly extended by the records of Andrew Murray and his correspondents, given in his important 'Catalogue of the Coleoptera of Scotland,' published in 1853. Equally noteworthy in this connection were Dr David Sharp's extensive

[1] Vol. i. p. 494. *Cf.* also Rev. W. Little's "Localities of Scottish Coleoptera" in vol. ii. p. 232. Records for the parish of Dalmeny were furnished by Dr Greville to the *New Stat. Acc.* (1843); and his son, R. N. Greville, sent notes on Coleoptera captured near Edinburgh and at Stirling to the *Zoologist* for 1843 and 1844.

[2] *Cf.* also Wilson's article on Entomology in *Encycl. Brit.*, 7th ed.

[3] *Cf. Proc. Berw. Nat. Club*, vols. i., ii., iii., vi., etc.

[4] *Cf.* our *Proceedings*, i. pp. 3, 258, 406, and ii. p. 260; also *Naturalist* for 1850 and 1851. In the *Zoologist* for 1845 and 1849, Stainton records a number of Lepidoptera from East Stirlingshire (Torwood, etc.), and in the same journal for 1847, some from East Lothian are given by A. Hepburn; also in 1849 there are a few by J. C. Howden.

researches, especially among the smaller Staphylinids, during the 'sixties.[1]

Early in the 'seventies we find Dr Buchanan White inaugurating an "Insecta Scotica," showing the distribution of each species according to natural areas, of which one is "Forth." The section dealing with the Lepidoptera (Macros only), edited by himself, was begun in 1872 in the first volume of the *Scottish Naturalist*—where the thirteen areas are defined and shown on a map—and concluded in 1879. The Coleoptera, by Dr Sharp, came out in the same magazine during the period 1872-1881; and the Trichoptera, by J. J. King and K. J. Morton, during 1884-1885. In these lists there are recorded from "Forth," 327 Macro-Lepidoptera, 1055 Coleoptera, and 53 Trichoptera. In this incomplete state the "Insecta Scotica" unfortunately remains to this day. During its progress, some additions to the Coleoptera were reported by Dr W. A. Forbes[2] and Sir Archibald Buchan-Hepburn.[3] Two visits to Aberlady by Mr G. H. Verrall, in 1870 and 1873, resulted in a further contribution to the scanty knowledge of Forth Diptera.[4]

A lull of a few years, then a revival of activity in which the chief workers have been Professor Hudson Beare (Coleoptera), Mr A. E. J. Carter (Diptera and Hymenoptera), Mr P. H. Grimshaw (Diptera), and myself, brings us to the present time. My own interest in Entomology (as also in Ornithology) began close on fifty years ago, when as a boy I lived in East Lothian, and came under the spell of Dr Charles Nelson of Pitcox,[5] a keen naturalist and kind-hearted man, whose memory I still cherish. For a long time my attention was practically confined to the Lepidoptera, then it embraced the Coleoptera, and latterly it has extended step by step to all the orders. The results of this latest wave

[1] *Cf.* papers by Rye and Sharp about this time in *Ent. Annual*, *Ent. Mo Mag.*, and *Trans. Ent. Soc. Lond.;* also note by W. R. M'Nab in our *Proceedings*, iii. p. 404, and Sharp's Thesis in Edinburgh University Library.

[2] *Scot. Nat.*, iii. p. 316. [3] *Ib.*, iv. p. 248, and *Proc. Berw. Nat. Club*, viii. pp. 132 and 314. In the *Entomologist* for 1888, A. Beaumont gives a number of records of Water-beetles from Culross, etc. *Cf.* also Notes by R. Logan in *Ent. Mo. Mag.* for 1887.

[4] *Ent. Mo. Mag.*, vols. viii., xii.; and *Scot. Nat.*, ii. p. 199.

[5] Dr Nelson's collection of British Lepidoptera is preserved in the Royal Scottish Museum. Unfortunately the specimens are without localities.

of interest in the entomology of the area, taken in conjunction with the previous work of which I have given a brief sketch, may best be told by a short statement under each of the orders.[1]

APTERA (COLLEMBOLA and THYSANURA).—Some ten or twelve years ago I found these lowly and much neglected insects, the Spring-tails and Bristle-tails, beginning to claim my attention, and having persuaded Professor Carpenter of Dublin to help me with the determination of my captures, material for a list rapidly accumulated. The results of our labours were embodied in a joint paper communicated to this Society in 1899, and, as regards a few additional species, in a subsequent paper submitted in 1904.[2] Adding *Isotoma minuta*, Tullb., of which I detected a few specimens among Collembola from Edinburgh water-cisterns, submitted to me by Dr Traquair in December 1905,[3] and a *Tetracanthella* from Ben Ledi in Sept. 1906, the list now stands thus—Collembola 63, and Thysanura (excluding one or two recent introductions) 4. About a score of the former were additions to the British list.

ORTHOPTERA.—The cockroaches, earwigs, and grasshoppers are poorly represented here, numbering, as far as we know, only a dozen species, and some of these not indigenous, though more or less established. A list of our Orthoptera will be found in a paper of mine in the *Annals of Scottish Natural History* for 1901.[4]

[1] I have endeavoured to give all essential references, but a complete bibliography is an impossibility here.

[2] "The Collembola and Thysanura of the Edinburgh District," by G. H. Carpenter and W. Evans, *Proc. R. Ph. S. Ed.*, xiv. pp. 221-266, 4 pls.; and "Some Spring-tails new to the British Fauna, with Description of a New Species," *ib.*, xv. pp. 215-220, 1 pl. *Cf.* also my Perthshire list in *Trans. Perth. S. N. Sc.*, iii. p. 150, and note on *Præmachilis hibernica*, Carp., in *Ann. S. N. H.*, 1907, p. 119. For fresh localities for a number of the rarer species, see my further paper published in a subsequent part of this vol., where some additional Collembola, bringing the number up to 66, are recorded.

[3] *Cf.* Sanitary Inspector's Report on insects found in cisterns and hydrants in Edinburgh, printed in March 1906. The commonest form, by far, was *Isotoma fimetaria* (L.), Tullb.

[4] "A Contribution towards a List of Scottish Orthoptera," *Ann. S. N. H.*, 1901, pp. 26-31. To the localities for *Stenobothrus parallelus*, I can now add Bavelaw Moss, Aug. 1901, and nr. Glencorse Reservoir, Pentlands, Sept. 1904. *Labia minor*, it may be mentioned, was common at Pettycur, Fife, flying in the sunshine, in July 1901, and *Gryllus domesticus* in a quarry near Slateford in June and July 1907 (*A. S. N. H.*, 1907, p. 250).

NEUROPTERA.—This heterogeneous group has been only partially listed in print. Reference has already been made (p. 50) to King and Morton's preliminary list of the Trichoptera (caddis-flies) in the "Insecta Scotica," and as regards the Dragon-flies, they have recently been the subject of a paper by myself in our *Proceedings*.[1] For some time past I have been working at the Neuroptera as a whole, and have now, with Mr Morton's help, a list of 226 species, made up as follows:—Mallophaga 45, Pseudo-Neuroptera 48, Odonata 11, Planipennia 27, and Trichoptera 95. The curious *Boreus hyemalis* (L.) I have met with on a good many occasions,[2] and in Trichoptera it has been my good fortune to take *Halesus guttatipennis*, M'L., *Limnophilus hirsutus* (Pict.), *Rhyacophila munda*, M'L. (the first and third additions to the Scottish list), and *Triænodes reuteri*, M'L., new to Britain.[3]

HYMENOPTERA.—Despite its extreme interest, the difficulties that beset the investigation of this large and bewildering order have deterred most of our entomologists from working at it. The Sessiliventres, or Saw-fly division, has received some attention from myself, the result, so far, being a list of 80 species, or about 60 per cent. of what may be expected to occur in the area. To the aculeate section (bees, wasps, and ants) of the Petiolata, I have given much more attention, and have now, awaiting an opportunity for publication, a list of 115 species, which cannot be far short of the total. This includes a few for the knowledge of which we are indebted to Mr A. E. J. Carter, who has also worked at the Aculeata of the district.[4] Of the few British Chrysids, I have met with only two here (see *Ann. Scot. Nat. Hist.*, 1901, p. 118);

[1] "The Odonata (Dragon-flies) of the Forth Area," *Proc. R. Ph. S. Ed.*, xvi. pp. 87-96 (1905).

[2] *Ann. S. N. H.*, 1897 and 1898.

[3] *Cf.* Morton, *E. M. M.*, 1906, pp. 65, 270; and Evans, *A. S. N. H.*, 1906, p. 56.

[4] Some years ago I submitted a preliminary list of our Aculeates to this Society, but being manifestly incomplete it was not published. Many of my records, however, in this and other groups of the Hymenoptera have appeared in recent vols. of the *Ent. Mo. Mag.* (1900, etc.) and *Ann. S. N. H.*, 1899, etc.; also in Morley's work on British Ichneumons. Carter's records are in the first-named magazine, and *Trans. Scot. N. H. Soc.*, 1901. In the old *Entomological Mag.*, iv. (1837) pp. 226, 235, Halliday recorded one or two Braconids from near Edinburgh. For much help in the determination of my Hymenoptera, I am indebted to Rev. F. D. Morice, E. Saunders, C. Morley, and A. J. Chitty.

and as regards the great parasitic section of the Petiolata, though I have collected them rather extensively, as yet only 130 species have been determined. Fully 100 of these are Ichneumonids, the rest being Braconids, Cynipids, Proctotrypids, Chalcids (a few of each), and the interesting aquatic *Agriotypus armatus* (*l.c.*, p. 183).[1] A collection of Chalcids made by Dr Greville, and exhibited by him—as appears from our minute-book—at a meeting of this Society on 12th April 1850, is in the Royal Scottish Museum. It contains "Edinburgh" specimens—over 20 are Walker's types[2]—of 201 "species."

COLEOPTERA.—The steps in the investigation of this extensive and favourite order have already been traced down to the close of Sharp's list. Since then, its further investigation throughout the area, from Isle of May to Balquhidder, with a view to the preparation of a fresh catalogue, has engaged much of my own attention;[3] and since coming to reside in Edinburgh a few years ago, Professor Hudson Beare has done excellent work in confirming old records and establishing new ones.[4] Taking all available data into account, I have now a list of over 1300 beetles for Forth. Of the 1000 or so species that I have myself met with, 150 are not marked "Forth" in Sharp's list, and there seems no reason why almost as many more additions should not yet be found. That the sub-order Strepsiptera occurs in the district I know from having twice caught stylopised bees (*Andrena fucata*); but what the species is remains uncertain.

LEPIDOPTERA.—To the combined lists of Lowe and Logan, and Buchanan White, mentioned on a previous page, I have been able to add considerably, more especially among the Micro-Lepidoptera,[5] and my Catalogue of the Butterflies and

[1] *Agriotypus* was first recorded for Forth (Loch Ard) by K. J. Morton in *E. M. M.*, 1894, p. 62. Re. *Antæon luffnessensis*, n. sp., *cf.* Chitty, *ib.*, 1908.

[2] *Cf.* Walker's papers in *Ann.* (*and Mag.*) *N. H.* for 1840 and 1846.

[3] See my papers in *Ann. S. N. H.*, 1900, pp. 91-101; 1903, pp. 89-99; etc. My great indebtedness to Rev. A. Thornley for help in the task of identification is there acknowledged.

[4] See *Ent. Record*, 1902, *et seq.* In *Ann. S. N. H.*, 1902, p. 56, W. A. Jolly recorded *Heptaulacus villosus*, Gyll., from North Berwick.

[5] *Cf.* my lists in *Ann. S. N. H.*, 1897, pp. 89-110; 1905, pp. 153-160; etc There are also recent records by Dr Carlier (*ib.*, 1892, p. 39) and others to be taken account of.

Moths of Forth embraces at present 758 species. There is need, however, of further work on the micros, from which numerous additions are certain to accrue.

Account for it as we may, there is abundant evidence that butterflies were formerly more plentiful in the district than they are now; indeed, we seem to have lost quite a number of species in the course of last century. In the older lists we find *Vanessa c-album*, *Pararge megæra*, *Pamphila linea*. and *P. sylvanus*, all of which must have vanished long ago, And I fear the Orange-tip, Peacock, Speckled-wood, and Ringlet—species I used to get in the Lothians when a boy, but never see now—have gone also. Gradually, too, the localities for some others are growing fewer; *Artaxerxes*, for instance, has not so far as I know been taken in its historic habitat, Arthur's Seat, since 1868.[1]

DIPTERA.—During the past decade a decided interest in the Flies has grown up, and the results are being published by Mr P. H. Grimshaw as a section of his "Diptera Scotica."[2] In the preparation of his Forth list, which so far as published includes 599 species, Mr Grimshaw has examined, besides those taken by himself, many specimens collected by A. E. J. Carter, J. Waterston, myself, and others. Adding some more that have been recorded,[3] and a number still unrecorded in my own collection, we have a substantial, though of course far from complete, list of 700 Diptera known from the area. This includes the sub-order Siphonaptera (fleas), of which I have recorded 23 species.[4]

THYSANOPTERA.—The species of Thrips in the district can hardly be less than 25,[5] but they have never been investigated, and there are practically no records. It is my intention

[1] "*Hesperia Artaxerxes*" was described by Fabricius in 1793 from a drawing of a specimen from Arthur's Seat (*cf. Nat. Lib.*, xxxix. p. 245).

[2] "Diptera Scotica: iii. and v.—The Forth District," *Ann. S. N. H.*, 1903, pp. 154-166, 212-226; 1904, pp. 26-33, 98-102; and 1906, pp. 154-161.

[3] [R. Henderson], *Trans. N. H. Soc. Glasg.*, vi. (n.s.), pt. iii. (1903) p. 338. Verrall, *Ent. Mo. Mag.*, 1904, p. 224, and 1905, p. 112. Carter, *E. M. M.*, 1905, p. 163, and 1907, pp. 110, 160. Evans, *Ann. S. N. H.*, 1905, p. 217, and 1907, p. 54, *E. M. M.*, 1908, pp. 207, 277; etc.

[4] *Ann. S. N. H.*, 1904, p. 193, and 1906, pp. 161, 241. Two others, namely, *Ceratophyllus insularis* and *Typhlopsylla dasycnemus*, have been recorded by Mr Waterston; *ib.*, 1906, pp. 212, 214.

[5] Halliday (*Ent. Mag.*, 1836 and 1837) described 40 as British, and no doubt there are quite half as many more.

to provide a list; this, however, will take time. As yet only 5 species have been made out, namely *Anthothrips statices* (Hal.), *Euthrips ulicis* (Hal.), *E. vulgatissima* (Hal.), *E. primulæ* (Hal.), and *Oxyothrips parviceps*, Uzel.[1]

HEMIPTERA.—Stewart gave the names of 24 Hemiptera in his list of Edinburgh insects (*l.c.*), and Greville collected them, but does not seem to have recorded his captures. They have recently engaged a share of my own attention, and I have now a list of 220 species.[2] The sub-order in which, thanks to the assistance of Mr E. Saunders, F.R.S., most progress has been made is the Heteroptera (bugs), of which 155 species have been identified. Fifty-eight Homoptera (hoppers, etc.) have been determined, but these are by no means all that have been collected, and very few Aphids and Coccids are included. The Anoplura (lice) account for the remaining 7 species.

The following Table, summarising the above, shows at a glance how matters stand as regards the class Insecta.[3]

ORDER.	Number of Species recorded or in my Lists.	Estimated Number in Area.
Aptera, ...	70	About 75
Orthoptera, ...	12	,, 12
Neuroptera (including Mallophaga), . .	226	,, 350
Hymenoptera (including Greville's Chalcids),	527	,, 1250
Coleoptera, ...	1328	,, 1400
Lepidoptera, ...	758	,, 850
Diptera, ...	702	,, 1300
Thysanoptera, ...	5	,, 25
Hemiptera (+Anoplura), ...	220	,, 450
Total, ...	3848	,, 5700

[1] Specimens of these and one or two other species have since been submitted to Mr Bagnall.

[2] Some years ago I brought before this Society a preliminary list of Hemiptera-Heteroptera, but a much more complete catalogue was desirable before publication. The more interesting of the records, and also some of Homoptera, have, however, been published in the *Ann. S. N. H.*; *cf.* 1900, p. 101, 1901, p. 184, 1905, pp. 57, 216, and 1906, p. 241. *Cf. ib.*, 1907, p. 225, for notice of a new louse (*Hæmatopinus ovillus*, Neum.) from the sheep.

[3] The number of recorded British Insects I make to be about 14,000.

TUNICATA.

The Ascidians or Sea-squirts, which form a sort of stepping-stone between the Invertebrata and the Vertebrata were a neglected group till Professor Herdman commenced to study them, when Dr Leslie and he were preparing their Catalogue of Firth of Forth Invertebrates, published in 1881. The number recorded in that Catalogue is 20, and the authors anticipated that further investigations would add largely to the list. Few further records appear, however, to have been published. Mr F. G. Pearcey, in his paper in the *Transactions of the Glasgow Natural History Society* (vol. vi., n.s., part 2), mentions a few species, among them being *Ascidia mentula*, O. F. Müll.—which is an addition to the list—from several stations in the Forth. An *Oikopleura* (*O. dioica*, Fol. doubtless) is, Dr Scott tells me, at times frequent in the Firth. Under the name of *Appendicularia* it will be found entered on a number of occasions in the Fishery Board's records of observations made on board the "Garland" during 1892 and 1893 (*cf.* 11th and 12th Reports, part iii.). It occurred during the summer months, and chiefly in the bottom tow-net. There is no evidence of *Salpa* ever having reached the Forth.

Seeing the Firth of Clyde can boast of 50 species of Tunicata, there seems no reason why the Firth of Forth should not possess say 40. Professor Herdman, with whom I have communicated on the subject, concurs in this estimate.

PISCES OR FISHES.

The Fishes of the Forth are, as a whole, well known. They were early observed and studied. Sibbald in the end of the seventeenth and beginning of the eighteenth centuries,[1] and Neill in the beginning of the nineteenth,[2] paid attention to them, and in 1838 Parnell's classic essay "On the Fishes of the District of the Firth of Forth,"—to use the title on the separately printed copies,—was published by the

[1] *History of Fife and Kinross*, 1710; *cf.* also new edition, 1803, in which the list of fishes is annotated, pp. 118-129.

[2] "List of the Fishes found in the Firth of Forth," *Memoirs of the Wernerian Nat. Hist. Soc.*, vol. i., pp. 526-555, 1808.

Wernerian Natural History Society (*Memoirs*, vol. vii.). Since then many scattered records have been made by local naturalists, including the Committee of this Society on Marine Zoology; and our knowledge of the Ichthyology of the Forth, in its faunal as well as in its economic aspects, has, in the course of the past twenty years, been very largely increased by the investigations of the Scientific Department of the Fishery Board for Scotland. The Board's Annual Reports (1885 *et seq.*) are full of tabulated data of faunistic value, while the rarer occurrences are recorded by Dr Wemyss Fulton and others under a separate heading. Rarities presented to the Royal Scottish Museum have been recorded from time to time by Dr R. H. Traquair. These records since Parnell's day, in so far as they relate to species additional to his list, or accounted rare therein, have been brought together by Mr W. Eagle Clarke in two papers published in the *Annals of Scottish Natural History* for 1900 (pp. 8-17, and 202-215). Parnell's Essay and Clarke's Supplements furnish us with what must be regarded as a very full list of the Fishes of the area. Adding three since obtained (see below), and *Rhombus norvegicus*, which I think may also be included, the number of species recorded to date is 143,[1] a figure not likely to be increased to any material extent. There is still, however, a good deal to be done before our knowledge of the Ichthyology of Forth can be said to be as complete as it should be. The fact that Parnell's list contains records of a dozen fishes not since known to have occurred in the area is not satisfactory and needs explanation, while the distribution of a number of species, especially among the smaller inshore forms, is still imperfectly worked out.

The following are some supplementary records, including the four above-referred-to additions to the list (they are marked *), of which I have a note:[2]—

Basse, *Labrax labrax* (Linn.) = *L. lupus* (Lacép.)—One caught at Kincardine-on-Forth, 5th February 1902 (Dr Wemyss Fulton, *Twenty-first Rept. Fish. Board Scot.*, part iii. p. 229). One, weighing about 2 lbs., captured off Elie in November 1904, is in the Royal Scottish Museum.

[1] This excludes one or two introduced fresh-water species.

[2] A few subsequent records, bringing the information down to the end of 1908, have since been inserted.

Black Sea-Bream, *Cantharus cantharus* (L.)—One—the second for Forth—17½ inches in length, caught in a salmon-net west of Aberlady on 13th April 1907 (W. Evans, *Ann. Scot. Nat. Hist.*, 1907, p. 148).

Bergylt, *Sebastes norvegicus* (Ascan.)—One seen by me in a fishmonger's shop in Edinburgh, December 1904, from "mouth of Firth of Forth," a phrase, however, which nowadays covers a good deal more than falls within our limits.

Greater Weever, *Trachinus draco*, L.—In January 1901 I obtained one, 12 inches in length, from the mouth of the Firth; and in October 1907, another, 8 inches, from off Anstruther.

*Blackfish, *Centrolophus niger* (Gmel.)—One, 20½ inches in length, was caught in a salmon-net at Largo Bay, 21st August 1901 (Dr R. H. Traquair, *Ann. Scot. Nat. Hist.*, 1902, p. 10).

Ray's Bream, *Brama raii* (Bl.)—Specimen from Firth of Forth, exhibited by Wyville Thomson at meeting of this Society, 4th December 1850 (Minute-book). Several others were got that winter. One, Dunglass, 1835 (*Trans. Berw. N.C.* i., p. 102).[1]

Yarrell's Blenny, *Carelophus ascanii* (Walb.)—One, 4½ inches long, found by me on Portobello west sands, 14th November 1901, after a N.E. gale (W. Evans, *A. S. N. H.*, 1902, p. 55).

Deal-Fish, *Trachypterus arcticus* (Brünn.)—♀, about 6 feet in length, found dead on the beach at Barnsness, near Dunbar, 28th November 1908; second record for Forth (Evans, *A.S.N.H.*, January 1909, p. 20).

Banks's Oar-Fish, *Regalecus glesne* (Ascan.)—♂, 13½ feet in length, stranded near Dunbar, 23rd May 1908; first authentic record for Forth (Evans, *A.S.N.H.*, 1908, p. 150).

Striped Wrasse, *Labrus mixtus*, L.—A male, 14⅛ inches in length, caught at Dunbar, 26th November 1877 (A. Brotherston, *Trans. Berw. Nat. Club*, viii. p. 522). There are only two prior and much older records.

Corkwing or Goldsinny, *Crenilabrus melops* (L.)—One dead on beach, North Berwick, 17th June 1899 (W.E.); one, caught on hook at Pettycur Pier, Fife, September 1908, is in the Museum, Edinburgh.

*Couch's Whiting, *Gadus poutassou* (Risso)—One, 8½ inches in length, caught in a net off Kincardine-on-Forth, 8th January 1902 (Fulton, *Twentieth Rept. Fish. Board Scot.*, pt. iii. p. 539).

*Norway Pout, *Gadus esmarkii*, Nilss.—One got close to Isle of May in May 1900 (Fulton, *Nineteenth Rept. Fish. Board Scot.*, pt. iii. p. 283).

Greater Fork-Beard, *Phycis blennoides* (Brünn.)—One, 21¼ inches in length, from outside the May Island, March 1904 (Evans, *Ann. Scot. Nat. Hist.*, 1904, p. 128).

Tadpole-fish, *Raniceps raninus* (L.)—One, from S. Queensferry, exhibited at meeting of Roy. Phys. Soc., 19th March 1884 (*Proc.*, viii. p. 503). One, N. Berwick, 1908 (W.E.).

[1] A very fine specimen, which I have examined in the flesh, found dead on beach at Fidra Point, North Berwick, 10th January 1909, and taken to Mr W. M. Ingles; length to fork of tail 21 inches, greatest depth 8½ inches.

*Norwegian or Ekström's Topknot, *Rhombus* (*Scophthalmus*) *norvegicus*, Günth.—One, a ♀, $3\frac{3}{8}$ inches in length, was captured on a fisherman's line 10 miles S.E. of the Carr Lightship [say about 5 miles east of Isle of May], 6th April 1893 (Prof. W. C. M'Intosh, *Twelfth Rept. Fish. Board Scot.*, pt. iii. (1894) p. 227).

Loach, *Cobitis barbatula*, L.—Widespread and locally common. Braid Burn, Lothian Burn, Tyne, Beil Burn, stream flowing out of Kinghorn Loch, and near St Andrews (Evans, *Ann. Scot. Nat. Hist.*, 1904, p. 127). Common in Threipmuir Reservoir, at the base of the Pentlands, where I found it plentifully in the bed of the stream in September 1905, when the water was unusually low. I mention these facts in view of a recent statement in Sim's *Vertebrate Fauna of Dee*, implying that the Loach is very rare in the east of Scotland.

Anchovy, *Engraulis encrasicholus* (L.)—A few captured near the mouth of the Forth by herring fishermen, January 1890 (Prof. J. C. Ewart, *Proc. Roy. Phys. Soc. Edin*, x. p. 333). One caught in herring-net off Buckhaven, 28th January 1902 (Fulton, *Twentieth Rept. Fish. Board Scot.*, pt. iii. p. 539).

Æquorean Pipe-Fish, *Nerophis æquoreus* (L.)—One obtained at Station IV., *i.e.*, South Bay, off Musselburgh (F. G. Pearcey, *Trans. Nat. Hist. Soc. Glasgow* (1900–1901), vi., n.s., p. 232). I have seen a specimen, 18 inches long, which was caught in a crab-creel near North Berwick in November 1907, and I have one, $15\frac{1}{4}$ inches, taken in the same manner off Dunbar on 23rd October 1908.

Short Sun-Fish, *Orthagoriscus mola* (L.)—One, $4\frac{3}{4}$ feet in length, and 6 feet from tip to tip of fins, captured at North Berwick, 28th September 1905. Attached to it, behind the anal fin, were a few specimens of the parasitic Copepod, *Læmargus* (*Orthagoriscola*) *muricatus*, Kröy. (Evans, *Ann. Scot. Nat. Hist.*, 1906, p. 57). Another, "about a stone in weight," was caught near Dunbar in October 1908.

Porbeagle, *Lamna cornubica* (Gm.)—One, fully 7 feet long, caught in cod-net about 3 miles off Fisherrow, 1st November 1904 (Evans, *Ann. Scot. Nat. Hist.*, 1905, p. 56).

Greenland Shark, *Somniosus microcephalus* (Bl.)—One, 11 feet in length, which came ashore alive at North Queensferry on 10th April 1906, was examined by me the following day. In its gills were numbers of the curious Trematode, *Onchocotyle appendiculata* (Kuhn) (Evans, *Ann. Scot. Nat. Hist.*, 1906, p. 187).

Angel-Fish or Monk-Fish, *Rhina squatina* (L.)—There is a small specimen in the Kelvingrove Museum, Glasgow, from "off Isle of May"; it was sent by Mr Ross, lighthouse superintendent, about a dozen years ago.

Note.—The Red Mullet (*Mullus barbatus*, L.) has been brought in by trawlers from the fishing grounds 30 to 40 miles outside the Isle of May, but I am not aware that it has ever been caught within our limits. Carp (*Cyprinus carpio*, L.)

have, I believe, now and then been introduced into private ponds in the district (as at Redbraes, Edinburgh, see *Naturalists' Library*, vol. xxxiii., Brit. Fishes, 1843, p. 48), but do not thrive.

AMPHIBIA AND REPTILIA.

For the sake of convenience I take these two classes together. They were fully dealt with in a paper which I read before this Society in 1894,[1] and there is little of importance to add to what I then wrote. The number of species recorded remains the same, namely:—

REPTILES, three—Viviparous Lizard, Slow-worm, Adder (I exclude the Ringed Snake, which occurs only as an escape[2]).

AMPHIBIANS OR BATRACHIANS, six—Common Frog, the two Toads (but the solitary record of the Natterjack is old and not entirely free from question), and the three Newts. Dr J. Beard tells me that he put some living Edible Frogs (*Rana esculenta*) into a pond beside the Queensferry Road (the marl-pit near Davidson's Mains probably) a year or two ago. I mention this so that, should anyone find them in that neighbourhood, their origin may be known.

With the view of bringing the subject down to date, the following records and observations are given by way of supplement to my paper above referred to:—

COMMON OR VIVIPAROUS LIZARD, *Lacerta vivipara*, Jacq.—One, $3\frac{1}{2}$ to 4 inches in length, was found in an old stone and lime wall which was being taken down at Stobshiels, foot of the Lammermoors, East Lothian, on 17th September 1906. None of the people about the place had ever seen one before (Mr C. C. Nisbet, *in lit.*) I still continue to see this little reptile occasionally, at Bavelaw Moss (August 1904, etc.) and a few other localities in Midlothian, but it is not common in this neighbourhood. In April and May 1896 I found it common enough, however, round about Aberfoyle, and in September 1906 I observed a dark, half-grown one on a peat-moss near the head of Glen Kelty, Callander. It is astonishing how long the tail of a lizard continues to move after being cast

[1] "The Reptiles and Batrachians of the Edinburgh (Forth) District," *Proc. Roy. Phys. Soc. Edin.*, vol. xii., pp. 490-526.

[2] In September 1899 one, which I saw, was killed in Canaan Lane, Morningside: it was known to be an escape. Other similar cases have recently come to my knowledge.

off. One which I timed near Killin last year "lived" for fully half an hour.

Slow-worm, *Anguis fragilis*, L.—I fear that now Blackford Hill is a public park within the city boundary, the Slow-worm is doomed to disappear from this old habitat. The last I have a note of from there was killed on 11th April 1901 [another occurred in 1908]. In June 1897 one was got in East Princes Street Gardens, and taken to the Edinburgh Museum (Director's Report for that year). At a meeting of the Royal Physical Society in November 1856, Prof. Fleming remarked "on the very local distribution of the Slow-worm, its great scarcity or total absence in this neighbourhood, and its apparent frequency in Clydesdale"; and Mr George Logan "mentioned he had taken one some years ago in Presmennan Wood, Berwickshire (*sic*), which he kept alive for some time" (*Proceedings*, vol. i. p. 191). In August 1894 I received a male from Doune, between Stirling and Callander; and in April 1896, and again in May 1897, the species was found to be fairly common in the neighbourhood of Aberfoyle, where on one occasion I observed one basking on a sunny bank in company with three adders—they were all mixed up. The tail of the Slow-worm, which itself escaped, and one of the adders were secured. In September 1897 a large specimen was captured near Denny, Stirlingshire, and taken to Mr Harvie-Brown.

Adder, *Vipera berus* (L.)—On 7th May 1898 an Adder, about 24 inches in length, was captured on Auchencorth Moor, near Penicuik, during a field-meeting of the Scottish Natural History Society. I had the facts at the time from Mr P. Adair, who was with the party. When staying at Aberfoyle in April and May 1896 and in subsequent years, I found the Adder quite common all over that neighbourhood. An adult pair, secured at one stroke on 26th April, measured as follows:—♂ $20\frac{1}{8}$ ins., of which tail $2\frac{7}{8}$ ins.; ♀ 22 ins., of which tail barely $2\frac{3}{8}$ ins. Others were—♂ 20 ins., ♀ $20\frac{3}{4}$ ins., ♀ 24 ins., and a half-grown one not measured. I have never measured an Adder more than $24\frac{1}{2}$ inches in length, but one evidently at least 27 inches (its captor called it 36!) was killed between Callander and Port of Menteith in 1867 (see letters in *Scotsman* of 22nd June and 30th July 1900). In the New Statistical Account the Adder is mentioned among the rarer animals found in the parish of Stirling (1841).[1] A circumstantial account of the capture of an Adder in a cricket-field at Blackford, Edinburgh, appeared in the *Scotsman* newspaper of 6th May 1895. The specimen (now in my possession) was, however, killed in Sutherland, and taken to the cricket-ground by way of a joke!

Frog and Toad—On 5th October 1894, in Pease Dean, near Cockburnspath, I caught one of the finest Common Frogs (*Rana*

[1] In the Old Statistical Account of Legerwood, Berwickshire (vol. xvi., 1795, p. 487), is the following: "Adders, although rare, are sometimes seen basking among the heath in the warm days of summer;" and they were reported to be unusually numerous in Lauderdale in 1864 (cf. *Zoologist* for 1865, p. 9457). This, however, relates to "Tweed."

temporaria) I ever saw. It was fully $3\frac{1}{2}$ inches in length, and beautifully marked. In wet spots, at elevations of 2400 feet on Ben Ledi and 2800 feet on Stuc-a-Chroin, Frogs were observed by me this autumn. Under a stone at about 2300 feet on Ben Ledi, I found a Common Toad (*Bufo vulgaris*), and last year one was met with still higher on the cliffs of Tarmachan (Tay).

Newts—In addition to the East Lothian localities mentioned in my former paper for the Warty Newt (*Molge cristata*), I have recently (1903) found the species in an old clay-pit at East Saltoun. In April 1896 I found the Smooth Newt (*Molge vulgaris*) in a quarry-hole about a mile east of Aberfoyle, and have also noted it at Drumshoreland (1894 and 1900), Ratho (1896), Bo'ness (1901), and Torry, Fife (1901). In addition to the numerous localities previously given for the Palmated Newt (*Molge palmata*), I have found it in an old quarry near Burntisland (February 1896), Pass of Aberfoyle (May 1896), and Loch-a-Chroin, 2500 feet altitude, adult females and young, common (17th September 1906).

AVES or BIRDS.

The most popular group of all is unquestionably that of Birds. For one person who takes heed of other groups of animals, there are scores who interest themselves in "our feathered favourites," and naturally there has been a corresponding annual crop of records—good, bad, and indifferent; indeed, the volume of records has now become so large as to be quite embarrassing. The result, however, is that the Avifauna of the area is well known: the list of species cannot be far from complete, and the faunal status of each can be given with much confidence.

Perhaps the earliest definite record relating to the Fauna of "Forth" is the reference in certain copies of Fordun's *Scottish Chronicle* to the great numbers of "Solendæ" or Gannets nesting on the Bass Rock. This entry appears for the first time in the abridged "Cupar MS.," written by Walter Bower, abbot of Inchcolm, between 1447 and 1449,[1] and therefore dates from the middle of the fifteenth century. But the foundation stone of our bird-list may be said to have been laid by the celebrated naturalist, John Ray, who visited the Bass in 1661, and has left a record of the species he met

[1] *Cf.* Skene's *Historians of Scotland*, vol. i. (1871), Preface. I have been at some trouble to fix the date of this record, as the usual statement, without qualification, that it is in Fordun's *Scotichronicon* gives the impression of an earlier date, seeing that Fordun lived in the fourteenth century.

with there (*Itineraries*, p. 192).[1] Of the writings and observations of Sibbald, Walker, Fleming, Neill, Macgillivray, Weir, Hepburn, Turnbull, Nelson, J. A. Smith, Gray, and the many others, still living, who have since contributed to the building up of that list, it is impossible now to speak; but in an account of the Ornithology of Forth, on which I am engaged, their contributions will receive due recognition. There are two publications, however, which I ought to mention here, namely, Macgillivray's lists of birds observed in the Lothians, given in vols. i. and ii. of his *History of British Birds* (1837 and 1839), and W. P. Turnbull's *Birds of East Lothian*, a booklet first published about 1855, and in a revised form in 1867.[2] Many notes and short papers by myself relating to the birds of the area have, I may say, already been published, chiefly in the *Proceedings* of this Society and in the *Annals of Scottish Natural History*. Pending the completion of the treatise alluded to, I have prepared a list of the birds in connection with this paper.[3]

There are various reasons, geographical, physiographical, etc., why the Forth area should possess a comparatively rich Avifauna. Its eastern boundary faces the North Sea, while its western extremity penetrates the Highlands of Perthshire. Besides the attractions of a highly diversified land-surface, it includes a noble estuary or firth, with rocky and muddy shores, and an island at its mouth lying right in the line of the east coast migration. This island—the Isle of May—has acquired considerable fame as a bird observatory in connection with the migration reports with which the names of Mr Harvie-Brown and Mr Eagle Clarke have been so long associated.[4] About twenty years ago I spent ten days on it, in the month of September, and witnessed the pheno-

[1] The number of gannets in the Bass colony has been variously stated. After many visits to the rock, and with a series of photographs covering the whole range of cliffs, which I took a few summers ago, before me, I estimate the number of nests at fully 3000, and the number of birds in the colony at between 7000 and 8000.

[2] *Cf.* R. Gray's notice of Dr Turnbull in *Proc. Berw. Nat. Club.*, vol. viii., p. 77.

[3] This list will probably be published separately.

[4] "The Isle of May: its Faunal Position and Bird-life," was the subject of an address to this Society by Mr Harvie-Brown in November 1886 (*Proceedings*, ix., pp. 303-325).

menon of migration, as it presents itself at a lighthouse tower on a favourable night. Much as we have learned from the Isle of May, it has still much to tell us.

My list of "Forth" birds extends to 248 species. Fully a dozen others have been recorded, but on evidence which in my opinion is insufficient; some, indeed, are palpable errors. On the other hand, there are half a dozen or more species, any of which might be detected on our east coast any year. I feel sure the Yellow-browed Warbler, the Barred Warbler, the Red-breasted Flycatcher, the Lapland Bunting, and Temminck's Stint, for example, visit us occasionally, and will yet be obtained.[1]

In order to show the character of our Avifauna, the 248 species might be grouped in various ways. For the present it may suffice to say that 125 of them have been found breeding in the area, 94 being residents out-and-out or partial, and 31 summer visitants; and that of the 123 non-breeders, 58 are winter visitants, 28 transmigrants or birds of passage, and 37 casuals that have occurred less than say five times in the area or just outside it.[2] It must be remembered, however, that it is a feature of our bird-life for many species to be partially resident and partially migratory. Thus, while some of our Song Thrushes are resident all the year round, a large proportion are essentially only summer visitants; others, again, visit us merely as birds of passage, and it may be that some play the part of winter visitants. Such cases, it will be seen, render satisfactory grouping difficult, and show the importance of the study of geographical races.[3] Land-birds, sea-birds, shore-birds are all, as one would expect, well represented in our area. The Golden Eagle, Ptarmigan, and Goosander reach in "Forth" the southern limit of their breeding-range in the eastern drainage areas of Britain, while the Grasshopper Warbler and Chiff-chaff seem as yet seldom to nest north of this. A marked

[1] Several additions to the list—including these two Warblers, which Misses Baxter and Rintoul have detected on the Isle of May (*A. S. N. H.*, 1907)—have been obtained since the above was written.

[2] Some of these will probably prove to be entitled to rank as birds of passage.

[3] British Song Thrushes are stated by Dresser and others to be darker in colouration than Continental ones.

feature in recent years is the increase in the number of breeding species, certain ducks—Shoveller, Pintail, Tufted Duck, and Pochard[1]—the Great Crested Grebe, and the Greater Spotted Woodpecker, being conspicuous examples. Less observable ones are the Hawfinch and the Pied Flycatcher. Many Woodcock now nest with us every year. Whatever other causes may have contributed to bring all this about, we may be sure the passing of the Acts for the protection of wild birds during the breeding season has been an important factor. The Stock Dove, formerly absent or very local and overlooked, is now to be met with throughout the district. Our known losses as nesting species include the Osprey, the Hen-Harrier, the Black Guillemot, and several Terns, though some of the latter show signs of returning.

As regards the complicated problems of migration—both in respect of the extent to which the various species participate in it and the routes followed—and of colonisation, much work remains to be done in different parts of the area before they can be solved.

MAMMALIA.

We have now reached the last or highest class in our scheme, namely, the Mammals.

For obvious reasons, the larger Mammalia forced themselves on the attention of our forefathers, and consequently references to them exist from a comparatively early date. Whales stranded in the estuary of the Forth formed the subject of Sir Robert Sibbald's *Phalainologia*, published in 1692. Much of the zoology contained in the Old Statistical Account of Scotland, written towards the end of the eighteenth century, and also a good deal of that in the New one, compiled forty years later, relates to such *feræ naturæ* as the Badger, Fox, Wild Cat, Marten, Polecat, Otter, Rat, Hare, Deer, etc. These and other old references to the native quadrupeds are most valuable for purposes of comparison, and enable us to trace the changes that have taken place in this section of our fauna. Bats, Shrews, Mice, and Voles were, however, very imperfectly known in those days, and down to 1891, when my account of the Mammalia of the district was first

[1] The Gadwall also is now (1908) breeding in the district.
So likewise is the Wigeon.

published,[1] the simple fact that they had occurred was all that was known concerning some of them. As regards the Cetaceans, they have been under the special care of Sir William Turner, and, needless to say, have been recorded with singular precision and fulness.

In my Memoir above referred to, besides giving the results of my own investigations, I endeavoured to bring together all the scattered records of any importance that were known to me. In a supplementary paper (since published[2]) I have brought the subject down to date. The number of Mammals recorded from "Forth" in these two papers is 50, of which 18 are marine and mostly casual visitors, only 3—the Common Seal (*Phoca vitulina*), the Porpoise (*Phocœna communis*), and the Beaked Whale (*Hyperoödon rostratus*)—occurring with any regularity or frequency. Of the 32 terrestrial species, 24 are more or less common and widespread, 5 are rare or very local, and 3—Wild Cat, Marten, and Polecat—are probably now extinct. The Whiskered Bat has occurred but once, the Black Rat is represented in these days only by a race or races confined practically to the shipping in the ports, while fresh records of the Harvest Mouse (*Mus messorius*) are much to be desired. An unproved but likely record of Natterer's Bat awaits corroboration.[3] The recent introduction of the Badger to Lord Rosebery's estates in Linlithgowshire and Midlothian is a fact in the local history of this animal necessary to be borne in mind.

Few additions to our list of Mammals can now be hoped for, though the Bats undoubtedly need further investigation, and an additional Cetacean or Seal may yet put in an appearance.[4]

[1] "The Mammalian Fauna of the Edinburgh District," with records of occurrences of the rarer species throughout the south-east of Scotland generally, published in *Proc. Roy. Phys. Soc.*, vol. xi. pt. i. (1891) pp. 85-171, and, with some slight alterations and additions, as a separate volume in 1892.

[2] "The Mammals of the Edinburgh or Forth Area—Supplementary Notes," *ibid.*, vol. xvi. No. 8, pp. 387-405, 1907.

[3] *Cf.* my paper on the subject in *Ann. S. N. H.*, 1901, p. 129.

[4] A White-beaked Dolphin (*Lagenorhynchus albirostris*, Gr.)—an ad. ♂ 8 feet 8½ inches in length—has since been captured near Cramond on 26th March 1907 (B. Campbell, *Ann. S. N. H.*, 1907, p. 65). The stranding of a Lesser Rorqual, 16 feet long, at North Queensferry on 3rd May 1905 is mentioned in the publications of the Dunfermline Nat. Soc. for that year, p. 7.

Having dealt separately with the various groups in turn there remains only the presentation of the necessary SUMMARY, which I give below in tabular form. It enables us to comprehend more clearly what has been done, and what there is still to do in the way of cataloguing the Fauna of the Forth Area; it furnishes, in a nutshell as it were, the answer to the question formulated at the beginning of the paper. Without wishing to make a comparison (that might profitably engage our attention on a future occasion), I may mention that the number of animals catalogued in the recent (1901) "Handbook" of the Fauna, etc., of the Clyde Area, is about 5930, inclusive of doubtful cases. With subsequent records, it must now exceed 6000. Taken all over, the fauna of Clyde will, I believe, prove to be richer than that of Forth both in species and individuals.

Phylum or other Group.	Number of Species recorded in print or in my MS. lists.	Estimated number in the Area.
Protozoa:—For details see p. 8,	306	800–900
Porifera, p. 13,	24	About 50
Cœlenterata and Ctenophora, p. 14,	123	,, 135
Echinodermata, p. 17,	34	,, 36
Platyhelminthes (Turbellaria, Trematoda, Cestoda), p. 18,	37	,, 170
Nemertinea, p. 22,	11	,, 20
Nemathelminthes (Nematoda, etc.), p. 24,	21	,, 150
Chætognatha, p. 26,	1	,, 2
Rotifera, p. 26,	170	,, 270
Gastrotricha, p. 28,	2	,, 5
Chætopoda, p. 29,	94	,, 220
Hirudinea, p. 31,	10	,, 17
Gephyrea and Phoronis, pp. 32, 33,	6	,, 8 or 9
Polyzoa, p. 34,	74	,, 85
Mollusca, p. 35,	339	,, 375
Arachnida + Linguatulida, pp. 39, 42,	431	,, 550
Tardigrada, p. 42,	17	,, 25
Pycnogonida, p. 43,	10	,, 12
Crustacea, p. 45,	796	,, 850
Myriapoda, p. 47,	33	,, 38
Insecta, p. 48,	3848	,, 5700
Tunicata, p. 56,	22	,, 40
Pisces, p. 56,	143	,, 145
Amphibia and Reptilia, p. 60,	9	,, 9
Aves, p. 62,	253	,, 260
Mammalia, p. 64*a*,	51	,, 53
Totals of all groups,	6865	,, 10,000

Of the above 6865 species, I have met with some 4250 in

the course of my own investigations. It will be observed that according to my estimate about one-third of the animals of the area have still to be discovered, so there is, at our own doors, plenty of faunal work to occupy us for years to come. In the working out of my collections I have availed myself to the full of the help of experts both in this country and abroad. With grateful acknowledgment of their invaluable assistance I may fittingly conclude this review.

Postscript, December 1908.—The delay in the issue of this paper is due mainly to a long and trying illness, from which I suffered last year. Records of any importance that have occurred in the interval are inserted, in order to bring the review down to date.[1] This accounts for a few discrepancies between the figures in the summary and those given earlier in the paper. I wish here to express my indebtedness to Dr J. H. Ashworth, who has kindly read a proof and in other ways given me the benefit of his extensive knowledge of invertebrate zoology and its literature.

[1] Some of my *Enchytræidæ* have since been described by Mr R. Southern in a paper on British and Irish Oligochæta, in *Proc. Roy. Irish Acad.* (vol. xxvii. p. 119); and in his series of articles on earth-mites, now appearing in *The Naturalist,* Dr C. F. George has described several of my *Trombidiidæ.* In the *Journal of Pathology and Bacteriology* (vol. xiii. p. 437), Drs Ashworth and MacGowan record the occurrence of *Trypanosoma cuniculi,* Blanch., in the blood of tame rabbits from the Edinburgh district. Bachmann's "Le plancton des lacs écossais" (*Arch. de Sc. phys. et nat. Geneve,* xxii., 1906, p. 359) should also be consulted.

Bachmann's lists, which include some Flagellata from Loch Leven, are in his "Vergleichende Studien über das Phytoplankton von Seen Schottlands und der Schweiz" (*Archiv für Hydrobiologie und Planktonkunde.* Stuttgart, Bd. iii., 1907).

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II. *Note on* Primnoa reseda *from the Færoe Channel, and on its Embryos.* By Professor J. Arthur Thomson, M.A. [With Two Plates.]

(Read 26th November 1906.)

A remarkably fine specimen of *Primnoa reseda,* Pallas, which used to be called the sea-mignonette, was obtained from the Færoe Channel (from a depth of 355 metres) in June of this year by the "Goldseeker," one of the vessels engaged in the International Exploration of the North Sea. Through the courtesy of Professor D'Arcy W. Thompson, C.B., I was able to see the splendid specimen a few days after capture, when the vessel came into port, and he has also given me permission to make this short note. The species—the only representative of the genus *Primnoa*—has long been known, but an examination of the beautiful specimen in its fresh state has revealed some new facts of interest, *e.g.,* as to the colour and the mode of reproduction. As one of the most gorgeous animals within the British area, it deserves some re-description in English, and a better figure than it has hitherto obtained.

The specimen was brought to the surface with its axis caught in a cleft in one of the boards of the trawl, and though without basal attachment, it was otherwise almost undamaged. It is almost a yard in height (34 inches), and its branches spread out for 16 inches. It far surpasses the specimen in the British Museum.

The axis, where bared at the base, has a diameter of $\frac{7}{16}$ths of an inch, and the average breadth of the branches, including the covering of polyp-calyces, is $\frac{3}{8}$ths of an inch. The colour of the colony, which soon began to fade, was *a brilliant salmon-pink*—a fact which I have not found mentioned in any of the descriptions. Some fragments which I preserved are now creamy white. The bare part of the axis at the base was a fine greenish-bronze, with a metallic lustre. In a class famous for beautiful representatives, *Primnoa reseda* must be accorded a high place, alike for its graceful branching and for its richness of colouring, not to speak of the elegance of the individual campanulate polyps. In its fresh

state it was one of the most beautiful animals I have ever seen.

My study of *Primnoa reseda* has been rewarded by the discovery of the interesting fact that the species is *viviparous*, and I have included at the end of the paper some notes on the embryos.

By way of contrasting the "Goldseeker" specimen with others previously obtained, I may briefly refer to a few of the old descriptions.

Linné (1728) called it *Gorgonia lepadifera*, and summed it up in the expressive words, "floribus sparsis consertis reflexis campanulatis imbricatis." He compared the polyp-calyces to barnacles, and noted that they were shut in by eight valves. He spoke of the cortex as *albidus*, but this seems to be only the post-mortem colour.

Pallas (1766) called it *Gorgonia reseda*, and gave a good description, alluding, for instance, to the resemblance between the close-set, recurved calyces and the fruits of mignonette, and to the branches thicker than swan's quills. He also speaks of the colour of the cortex and calyx-scales as white, whereas it is a vivid salmon-pink in the fresh specimen. He gives its locality as "mare norvegicum et forte indicum," but the suggestion of the Indian Ocean was probably due to some mistake.

In 1786 Ellis and Solander described it as "the barnacle-bearing Gorgon" (*Gorgonia lepadifera*), and noted the dichotomous branching, the bell-shaped, scale-covered calyces, the minute whitish scales covering the flesh, and the bone-like axis. The size is given as usually 18 inches high (contrast the 34 inches of our specimen); the locality is stated as the coast of Norway, but the specimen figured came from Archangel. Attention is directed to the eight valves covering the mouth, which are compared to the scales on the head of the horned asp, *Coluber cerastes*. "In this *Gorgonia*, which is a fixt animal, the scales on the stem and branches, which do not move, are much of one form, differing greatly from those on the heads, which are always in motion, while the animal is alive and catching its food." The downward bent heads and mouths are compared to "some species of barnacles,"

just as others had compared them to fruits of mignonette (*cf.* Clusius, "Planta marina Resedæ facie"). The two figures given by Ellis and Solander are fairly good.

Esper (1794) devoted about eight pages to the "sea-acorn horny coral," realising that it occupied a position by itself. But he was entirely mistaken in his interpretation of the animal, imagining that he had to do with an axis like that of *Antipathes*, on which little creatures related to barnacles had settled down! Yet his description, partly based on those of Gunnerus and Baster, is very accurate, and, as his work is somewhat inaccessible, I may be allowed to make a few extracts in free translation. The barnacle-bearing Gorgon is confined to Norwegian coasts, and does not occur in Icelandic waters; a height of 6 to 8 inches is common, but a large specimen was 2½ feet high; most of the branches are truncate, but some taper; the colour of the fresh axis is greenish, but it soon becomes brown; the axis is horny and stony, and covered by fine longitudinal lines; there may be forty-eight campanulate shells or "houses" on an inch; the colour when fresh is yellow, but it soon becomes dirty white; in most cases the mouths of the houses were towards the tips of the branches, but a few were turned in the reverse direction, and some were quite awry; the houses are formed of rows of imbricating brittle scales, with 6-8 parts making a lid; but the houses do not really belong to the coral, for while it is related to *Gorgonia antipathes*, they are related to barnacles (*Lepas*).

It was Lamouroux who first recognised the essential peculiarities of this type, separated it from Gorgonians, and established the genus *Primnoa*.

In the *Edinburgh New Philosophical Journal* for 1847, Charles Stokes wrote as follows:—"*Primnoa lepadifera* is found, I believe, only on the coast of Norway. I have specimens nearly 2 feet in height, which were presented to me by Sir Arthur de Capell Brooke, Bart., who collected them there in 1820. He received accounts of their growing to a much larger size. They are found at great depths, varying from 150 to 300 fathoms. At these depths they grow in company with a large branching Alcyonium of a red

colour (*A. arborea*)." The latter is now named *Paragorgia arborea.*

He goes on to say that "the polype cells of *Primnoa* are membranaceous and covered with calcareous scales, . . . these scales do not cover the whole surface of the cells; on the inner side, next to the stem, there is a part devoid of scales, as if, being less exposed, their protection was not needed. . . . The substance of the cells being membranaceous, they are movable in all directions, as is shown by the different positions in which the cells of *P. lepadifera* have dried, and hence a mistake was made by Ellis, who described the cells as 'reflexed,' that is, with the mouth downwards, which must have arisen from the position in which his specimens had been hung up to dry, as the weight of the cells would make them fall."

As the "Goldseeker" specimen was, naturally enough, not "hung up to dry," it may be interesting to note that while the great majority of the polyps were reflexed, a few among them had the mouth pointing upwards. They are so stiffly encased in scales that one finds it difficult to believe that they could possibly turn upon their bases of insertion. It is surely a growth-variation.

In his brief paper, Stokes refers to his figures of a *Primnoa rossii*, n. sp., which Sir James Clark Ross had obtained from a great depth (see his *Voyage to the Southern and Antarctic Regions*, vol. i. p. 334). This new species seems to have been left undescribed, but Dr J. Versluys notes in his splendid monograph on the Siboga Primnoidæ that it was perhaps the same as Gray's *Hookerella pulchella*, which was also left practically undescribed. A specimen in the British Museum, labelled *Hookerella*, seemed to Versluys to agree closely with his *Thouarella tydemani*, but a comparison of the polyps was not made. Thus, so far as we know, *Primnoa reseda* remains the only species of its genus.

In 1861 E. Grube described "a new coral"—*Lithoprimnoa arctica*—from the Norwegian coast, in 70° N. lat. This is, again, *Primnoa reseda*, Pallas. I have not been able to consult Grube's somewhat inaccessible paper, but there is a notice of it in the *Annals and Magazine of Natural History*

for 1863, p. 166. He describes the axis as greyish-white, whereas it was greenish-bronze in our specimen; he speaks of the concentric layers of lime amid the black cornein; and says that the calcareous scales on the bodies of the polyps and the eight oral valvules approximate it to *Primnoa lepadifera*, with which it is indeed identical.

It is interesting to notice that Verrill found *Primnoa reseda* in deep waters at St George's Bank in the Bay of Fundy. In the description which he gave in 1866, there are several points which disagree with what our specimen shows. He says: "Trunk large, arborescent, branching in a dichotomous manner, often very thick and stony near the base; branchlets round, tapering to slender flexible points; cells large, campanulate, irregularly scattered." But in our specimen the branching is only irregularly dichotomous, the branches do not taper to slender points, and the cells, though not in whorls or spirals, are closely crowded, and cannot be spoken of as scattered. Verrill also says that "the cells are capable of moving in different directions, but in preserved specimens are generally turned downwards." As already noted, we cannot believe in much mobility of the polyp-calyces.

Gray's description also leaves a good deal to be desired. He refers to "the large basins or cups of the shape of bent reeds, membranous on the concave side, on the convex side covered with large imbricated overlapping scales. At the mouth of the cup the scales form a ring, and are eight in number, within which, in the retracted polypes, there is a coniform outstanding lid, which is formed out of eight long flat scales. Besides, the polypes at the base of the branches possess eight rows of small calcareous bodies (spicula), and indeed, small out-pressed double clubs, covered with small warts and spines, approaching to simple spicules." He defined the species as "a coral alternately branched, diffused; bark with crowded, callous, recurved calyces."

In his diagnosis of the genus *Primnoa*, Gray says: "Coral branched, tree-like; branches cylindrical, forked. Bark formed of scales. Polypiferous cells ovate, clavate, dependent, covered with two series of large convex imbricate

scales, placed in whorls of three round the branches." But they are characteristically *not* in whorls in *P. reseda,* the only known species. The aperture, he says, is closed with *three* pointed scales, yet he himself points out that *P. reseda* has *eight.* "The axis is horny [really very calcareous as well], black [really burnished green-bronze], solid, cylindrical, the base being often covered with a hard calcareous longitudinally striated outer coat."

In his monograph on the Primnoidæ—a model of thorough and thoughtful workmanship—Dr J. Versluys abstains from a re-description of *Primnoa reseda,* because it is so readily recognisable. He gives the following diagnosis:—"The polyps may be closely apposed to the twigs, as in *Caligorgia,* by their almost naked adaxial surface; only two abaxial rows of sclerites are well developed. At the upper margin of the calyx there are eight sclerites, each of which bears an opercular scale, and of these, as of the sclerites which bear them, the four adaxials are distinctly smaller than the four abaxials." "The branching is irregularly dichotomous, and relatively sparse. The colony spreads out, predominantly but not exclusively in one plane. The polyps are not in verticils, but are disposed irregularly and somewhat densely; they are not in spirals."

Geographical Distribution.—Versluys sums up the distribution of *Primnoa reseda* as: North Atlantic, coasts of Scotland, Shetland Islands, Norway, White Sea, and on the American coast at St George's Bank, Bay of Fundy. Stokes says off Norway; and the British Museum specimen, presented by Dr Carruthers, is from the same region. The specimen described and figured by Ellis, presented to him by Solander, came from Archangel. Gray notes North Sea; Setubal (Prof. E. P. Wright); England (Johnson). In his *British Animals* Fleming notes, "This species, which is common on the Norwegian coast, has been found, according to Professor Jameson (*Wernerian Memoirs,* vol. i. p. 560), at Zetland and Aberdeenshire." We have now to add, Færoe Channel.

Embryos.—As I have mentioned, my study of *Primnoa reseda* has been rewarded by the discovery that this species

is *viviparous.* Another form must therefore be added to the growing list of Alcyonarians in which viviparity has been demonstrated (see Thomson and Henderson in the list of References).

Many of the polyps in the fragments at my disposal were found to be crowded with embryos, but most of them were unfortunately at the same stage of development. As we have very few data in regard to the development of Alcyonarians, except the memoirs of G. von Koch, Wilson, Kowalevsky and Marion, and Lacaze-Duthiers, the following notes may be of service.

Attached to the mesenteric bands there were elongated clusters of ova at different stages of ripeness. Some of these were seen to have a very definite envelope, from which a stalk ran to the mesentery. Other larger egg-like bodies were lying freely in the cœlenteron. An examination of these showed that they were already well advanced in development, that they were, in fact, diploblastic *embryos.* Most were spherical or slightly ovoid, and some showed an invagination at one pole. A few were solid, most showed a well-developed cœlenteron. The following measurements of the diameter or of the longer axis were taken :—0·4, 0·5, 0·6, 0·7, 0·8 mm. In many cases the wall was about 0·1 mm. in thickness, of which about four-fifths was due to the inner layer.

The ectoderm consisted of a single layer of columnar cells, sometimes with large vacuoles; the endoderm consisted of a dense mass of small cells, in the middle of which there was usually a large cœlenteron. In most of the sections the endoderm appeared like a syncytium, and about half a dozen nuclei lay on every radial line across the wall one chose to follow. A very distinct double-contoured middle-lamella or mesoglœal plate lay, like a double basal membrane, between the ectoderm and the endoderm.

It seems, therefore, that we have to do with planulæ, very clearly differentiated into two layers, the inner of which is several cells thick. It is probable that the cœlenteron is formed by histolysis in the middle of the endodermic mass. There was no trace of typical gastrulæ. It is likely that the invagination or dimple seen in many cases at one pole is the

beginning of the stomodæum. Only in one section was there a hint of a blind stomodæal insinking insinuating itself into the cœlenteron, but the appearance was not sufficiently definite to be convincing.

Apart from the embryos, I have found little that is new to report, but I thought it might be both useful and interesting to gather together some of the references to this very beautiful northern Alcyonarian, and to submit these to a Society which has been for so long a repository for observations on the Scottish Fauna.

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Reference to Plates.

Plate I. Photograph of the Colony.

Plate II. A Twig in Natural Size and Colour.

III. *The Development of* Polypterus. By Professor J. Graham Kerr, M.A., F.R.S.E.

(Read 17th December 1906.)

[Abstract.]

Professor Graham Kerr gave a general account of the development of *Polypterus*, based upon a study of the material obtained in the Niger delta by the late J. S. Budgett. The material consisted of a number of eggs of *P. senegalus* which had been artificially fertilised. From native reports it appeared that the eggs are in nature attached to the surface of sticks, water plants, etc., near the surface of the water in the lateral lagoons. After hatching, the young fish are said to move about in a dense shoal with the parent (? probably the male) swimming above them. There is no direct evidence as to whether fertilisation is internal, though the erectile character of the anal fin suggests this.

The external features in development have been already given in outline,[1] and will be fully described and illustrated in the Budgett Memorial Volume.[2] As regards internal features, the following are the main points of interest:—

Enteron.—The buccal cavity is from the beginning widely open, *i.e.*, it is not formed by secondary excavation of an originally solid rudiment, as in Amphibia and Dipneusti. The secretory epithelium of the cement organs is endodermal in origin, arising as a pair of diverticula of the anterior end of the gut, resembling gill-pouches or coelenteric pouches. These eventually lose their connection with the endoderm, and become fused with the ectoderm. They appear to be serially homologous with gill-pouches, and the question is raised whether, in spite of the present balance of evidence, there may not be a primitive serial homology between gill-pouches and coelenteric diverticula in the vertebrate. The lung rudiment is at first median and ventral. The pancreas arises from three primary diverticula of the gut wall, one dorsal and two ventral. The "liver" of *Polypterus* is really

[1] *Report Brit. Ass.*, Cambridge, 1904.

[2] Cambridge University Press, 1907.

a hepatopancreas—the pancreas forming a superficial layer over part of its ventral surface. The spiral valve is foreshadowed by a spiral coiling of the gut rudiment. There is a well-developed solid postanal gut, which eventually breaks up and disappears. The hypochorda develops a distinct "primary sheath," and its cells show vacuolation like those of the notochord.

Coelomic Organs.—The two nephrostomes which characterise the functional pronephros belong originally to metotic mesoderm segments II. and V. Segment I. develops a tubule rudiment which soon disappears; segments III. and IV. develop tubules which also gradually atrophy while those of II. and V. are becoming enlarged. Behind segment V. a number of doubtful tubule rudiments are found. In its later stages the pronephros becomes very large, due to the great growth of the anterior part of the archinephric duct and of the two functional tubules. Separate glomeruli occur in pronephric chambers B and E (*i.e.,* the pronephric chambers of segments II. and V.). Both pronephric tubules are still visible in the 30 mm. larva. The mesonephric tubules develop independently both of duct and of coelomic lining.

Vascular System.—The cavity of the dorsal aorta is formed by the fusion of vacuoles in masses of protoplasm derived from the sclerotomes. The endocardium is apparently mesodermal in origin. The blood-corpuscles make their appearance quite suddenly in the already formed blood-vessels: it is suggested that they are mesodermal cells set free from their neighbours by the drawing in of cell processes accompanying an epidemic of mitosis. During a prolonged period only one pair of aortic arches are present—those of the external gills (hyoidean). The *ductus Cuvieri* are at first simply portions of the general vitelline network. In its later stages the venous system becomes strongly asymmetrical, the anterior end of the left posterior cardinal, and the left inferior jugular becoming much reduced.

Skeleton.—The material is too fragmentary to show details of the early development of the skeleton; it may be noted, however, that the skull in its early stages shows marked resemblances to that of Amphibia, that a single pair of

large occipital arches are present between metotic myotomes I. and II., and that the skeleton of the pectoral fin is in the earliest stage investigated in the form of a continuous plate of cartilage.

Central Nervous System.—In addition to points mentioned in my previous communication,[1] it should be noted that in the adult *Polypterus* there is a well-developed cerebellum which projects forwards as a *valvula cerebelli* as in Teleosts, but, in addition, projects backwards in a quite similar manner into the cavity of the fourth ventricle. No cerebral hemispheres are pushed out from the sides of the primitive forebrain, the material which would form them being accommodated by (1) thickening of the wall of the primitive forebrain, (2) increase of its length, and (3) slight invagination into the third ventricle. The conditions in *Polypterus* support the view that the so-called "membranous pallium" of the Teleostomatous fishes is simply the roof of the Thalamencephalon, and is not actually homologous with the "pallium" of higher forms.

IV. *Meristic Variation in the Common Sun-Star* (Solaster papposus). By D. C. M'Intosh, M.A., B.Sc., F.R.S.E.

(Read 17th December 1906.)

The purpose of this Note is to record the variation in the number of arms in the Common Sun-Star (*Solaster papposus*) as found in an examination of 612 specimens collected in the Clyde area at intervals during 1902, 1903, and 1904. The material examined was dredged by the S.Y. "Mermaid," belonging to the West of Scotland Marine Biological Association, and it was while occupying, through the kindness of Professor J. Arthur Thomson, the Aberdeen University Table at the Millport Station, that I gathered the facts herein recorded. *Solaster papposus*, though widely distributed, is not exactly a common animal in these waters. When dredging, one rarely takes a haul without getting a few specimens, but generally these number less than half a

[1] *Proc. Roy. Phys. Soc.*, Vol. XVI. p. 191.

dozen—a probable indication that this animal is not gregarious in habit like some other Echinoderms, for example, *Ophiocoma nigra.* Consequently, it took a lengthened period to collect six hundred of them, and even that number could not have been obtained but for the kindness of Mr Alex. Gray and Mr Thomas Hill, who were then in charge of the Station, and who kindly preserved many for me. As to the relative frequency of certain Echinoderms in the Clyde, I have no actual figures, but I may state my impression that at least ten specimens of *Asterias rubens,* and more than double that number of *Echinus esculentus,* are dredged for each *Solaster papposus.* On the other hand, about ten specimens of *Solaster papposus* are found for every *Asterias glacialis,* and more than double that number for every *Luidia fragilissima.*

Unlike most Echinoderms, which show in adult form a perfect pentamerous symmetry, *Solaster papposus* is well known to have a variable number of rays, and the following extract from Forbes's *British Starfishes* may be taken as giving the commonly accepted view: "The rays are generally twelve or thirteen in number, sometimes as many as fifteen." The following Table, which represents the facts as found by me, is self-explanatory.

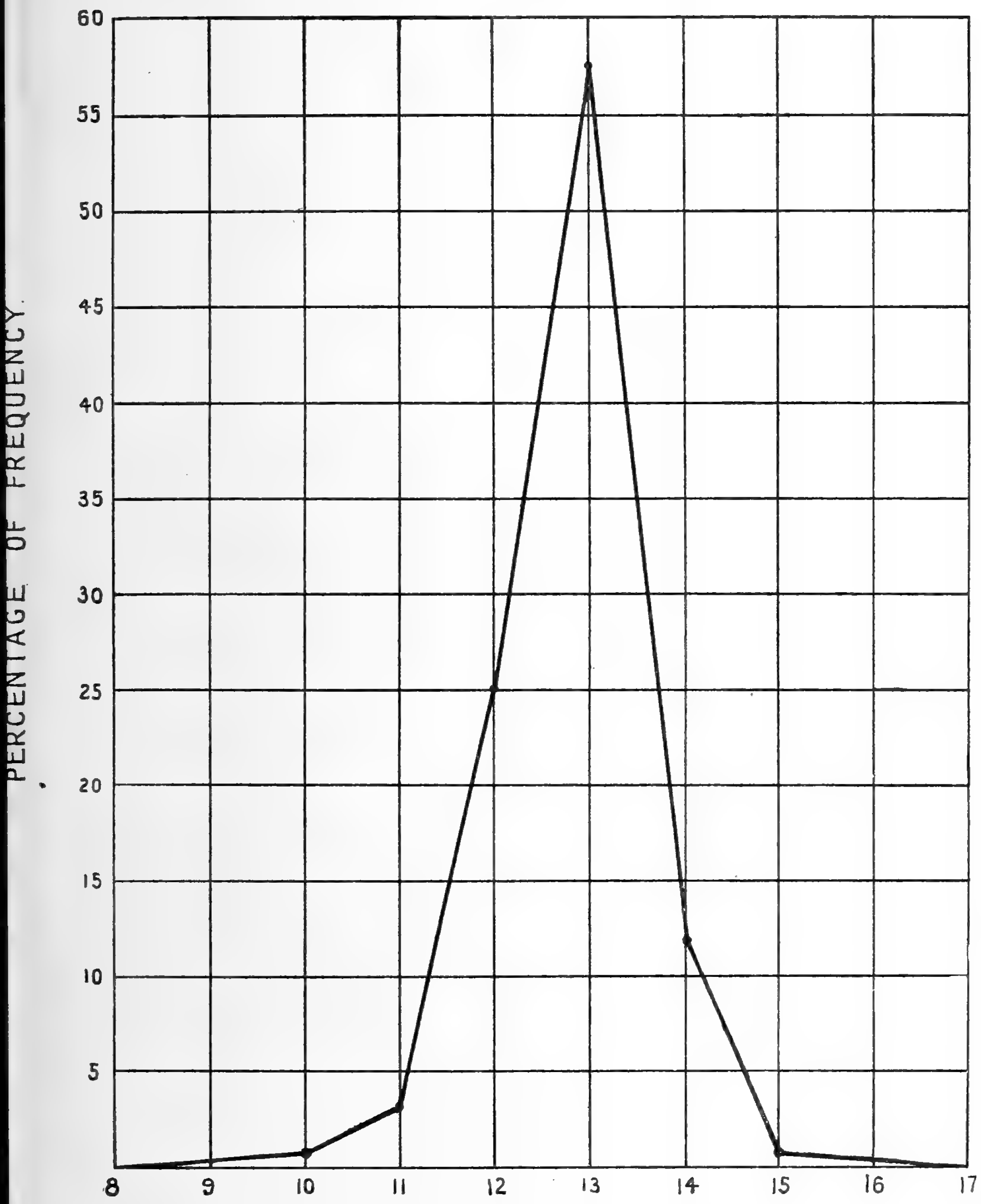
Variation Table.

No. of Arms, . .	9	10	11	12	13	14	15	16	Total.
No. of Specimens, .	1	8	19	154	351	72	6	1	612
Percentage, . . .	0·16	1·3	3·1	25·1	57·4	11·8	0·98	0·16	100

It will be observed that the total range of variation as here shown is from nine to sixteen rays. The solitary nine-rayed specimen was dredged from shallow water with muddy bottom opposite Mount Stuart, on the east side of Bute. I have preserved this specimen, which is still quite undamaged. It has none of the characteristics of the Purple Sun-Star (*Solaster endeca*), but is distinctly a nine-rayed

Solaster papposus. It measures 11 cm. across, the diameter of the disc being 5 cm., and the arms, which are of equal length, 3 cm. each. It is clearly an immature specimen, and

POLYGON OF FREQUENCY.



NUMBER OF ARMS.

smaller than the average of those dredged. The Table also shows that over 57 per cent. are thirteen-armed, and that while 13 per cent. have over that number of arms, 30 per

cent. have less. Further, twelve, thirteen, and fourteen-rayed animals account for 94 per cent. of the total.

The accompanying "Polygon of Frequency" diagram shows very clearly the prevalence of thirteen-rayed Solasters. A curve, which is a simple uni-modal one (Pearson's Type IV.), constructed from these figures after the manner of writers in *Biometrika*, would portray the facts even more graphically, and would involve the following factors:—

Mean, ...	= 12·7827
Standard Deviation, . . .	= 0·8024
Coefficient of Variability, . .	= 6·2771
Probable Error of Mean, . .	= ±0·02187
Probable Error of Standard Deviation, .	= ±0·01546
Average Deviation, . . .	= 0·5896
Asymmetry, ...	= 0·1468

V. *On the Occurrence of a Supposed Australasian Hydroid* (Sertularia elongata) *in the North Sea.* By James Ritchie, M.A., B.Sc., University of Aberdeen. [Plate III.]

(Read 28th January 1907.)

In November 1904, Mr J. J. Simpson, M.A., B.Sc., while searching for chance specimens in the nets of the trawlers lying at Aberdeen Fish Market, came upon a magnificent cluster of Hydroid colonies, which he kindly handed to me for identification.

The colonies, of which there were about forty-five in the bunch, are fixed upon a slender twig, 0·2 mm. in diameter and 11 cm. in length, which is in many places encrusted by Polyzoa. They vary considerably in size, the largest about 8 cm. in height and 1·5 cm. in breadth, the smallest about 2 cm. by 0·45 cm. When Mr Simpson found the specimens, the cœnosarc had already wholly disappeared. Both the hydrocaulus and the gonothecæ (which are numerous, some of the colonies bearing a gonotheca on almost every pinna) agree specifically with the descriptions and figures of *Sertularia elongata,* Lamx., given by Prof. D'Arcy W.

Thompson (1879), by Bale (1884), and by Allman (1885). Our specimens do not show more than three pairs of hydrothecæ on any one internode, while Bale records that four or even five pairs occasionally occur, nor are there present branches of other than the regular pinnate order. But in these respects our specimens agree with those of Prof. D'Arcy W. Thompson, C.B., to whom I am indebted for the opportunity of examining his fine collection.

As to the known distribution of *Sertularia elongata*, so far as we can learn, it has been recorded from the south coast of Australia, where Bale (1884) says it is one of the most common species, more particularly from Cape Wilson, Port Philip, etc., in Victoria (Dr F. Müller, cited by Thompson, 1879); from Tasmania (Allman, 1885), particularly from Georgetown and Bass's Straits (Dr Harvey, cited by Thompson, 1879); from West Australia (Allman, 1885); from New Zealand, where the species is less common than in Australia (Gray, 1843; Hutton, 1872; Coughtrey, 1874), particularly from Lyall Bay, Wellington (Farquhar, 1895), and Kuri and Taieri beaches, Otago (Hilgendorf, 1897). That is to say, the distribution is limited to Southern Australasia. The West Australian locality of Allman is of special interest because, while our specimens differ in detail from his Tasmanian examples, they agree absolutely with the West Australian form in all the points which he singles out as peculiar to it.

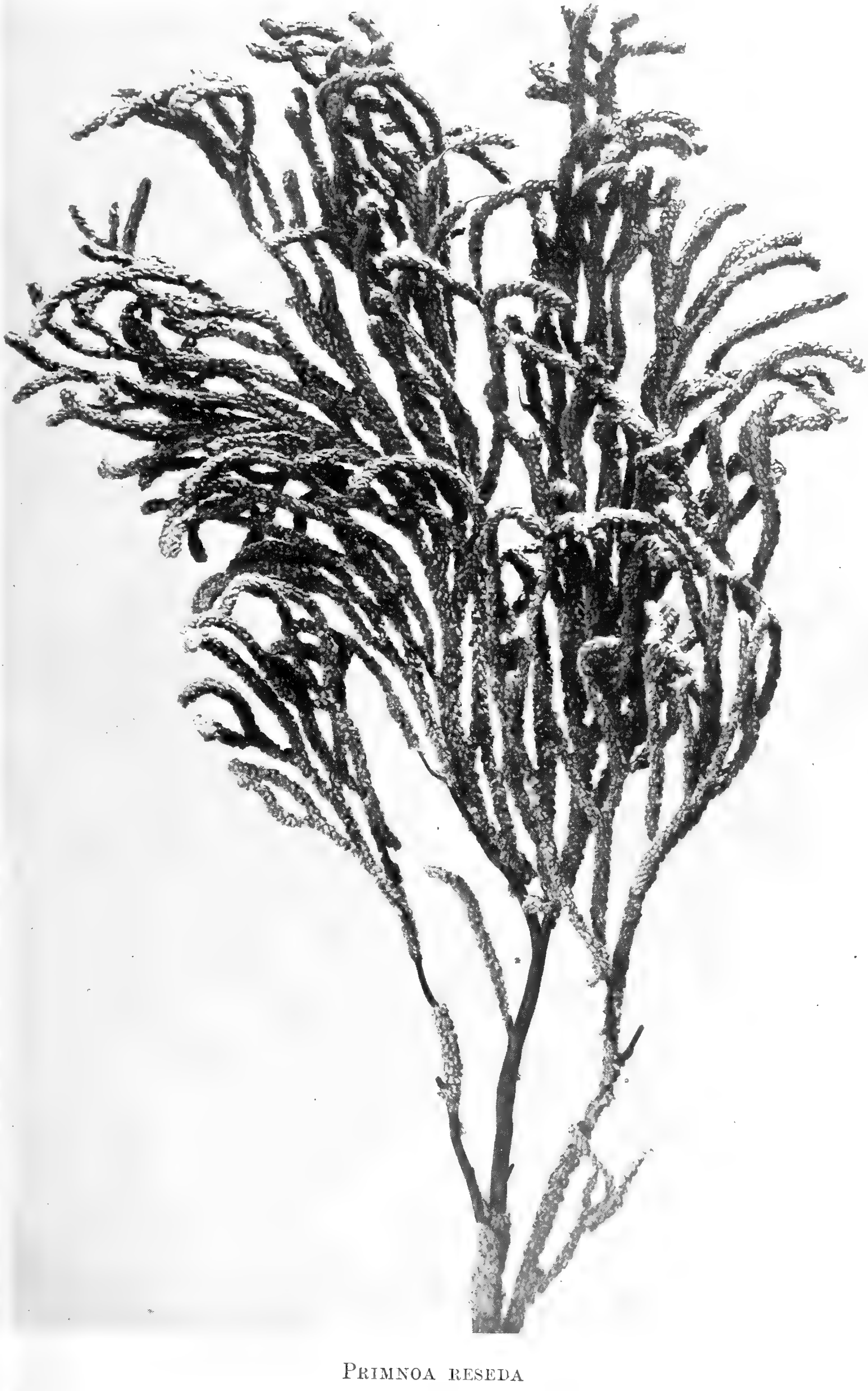
The trawler in whose net the present specimens were found had been trawling off the Shetland Isles, and, on the return journey to Aberdeen, off Buchan Ness, the last haul having been taken in the neighbourhood of the "Buchan Deep." Consequently, the presumption is that the specimen found in the trawl-net came, if not from the last haul in the "Buchan Deep," at least from some locality in the North Sea. It remains to account for the presence of a species, so distinct and with so limited a distribution, in the North Sea. Three possibilities suggest themselves—(1) that the species grows in the North Sea; (2) that the specimen was brought thither attached to the bottom of a ship, as *Tubularia crocea*, Agassiz, was, in 1895, brought from Peru to Plymouth Sound

(Browne, 1899); (3) that the specimen has drifted thither from its Australasian locality.

The twig to which the colonies are attached helps to a conclusion. Cross and longitudinal sections are characteristic, showing a central strand of sclerenchyma surrounded by loose lacunar tissue, which again is surrounded by a thick band of sclerenchyma. The twig and sections were shown to Prof. J. W. H. Trail, M.D., F.R.S., to whom I am indebted for kind assistance, and he pronounced the branching and microscopic structures to be those characteristic of the marine phanerogams of the subfamily Cymodoceeæ in the family Potamogetonaceæ. This subfamily contains but nine species, all of them, with one exception, belonging to tropical or south temperate seas, the majority occurring in West Indian, Indo-Pacific, and *Australian* waters (Engler and Prantl, 1889). The exception, the only north temperate form (*Phucagrostis major*), occurs in the Mediterranean Sea and along the Spanish and African coasts, but its structures are quite distinct from those of the present specimen, and it may therefore be left out of consideration. If, then, it is assumed that the North Sea Hydroid specimen grew upon the plant *in situ,* and it is the habit of *Sertularia elongata* to grow upon seaweeds (*vide* Bale, Allman, etc.), the twig may be taken as indicating a tropical or south temperate origin for the specimen.

Since so conspicuous a Hydroid has not been recorded by any of many careful workers, and has not been found in many recent dredgings, from the North Sea, and since it has grown upon an exotic plant, the first supposition, that the species grows in the North Sea, may be rejected. The second supposition is also rendered impossible, because the very fact that the specimens have grown upon a twig excludes the possibility of their having been attached to a ship's bottom and thus transported. The conclusion remains, and it is indicated by the known distribution of *Sertularia elongata,* as well as by the characters of the twig to which the specimens are attached, that the North Sea specimen has drifted, probably from an Australasian, perhaps from a West Australian, locality to the spot where it was picked up.

PLATE I.



PRIMNOA RESEDA

PRIMNOA RESEDA

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PRIMNOA RESEDA

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The ocean currents are not inconsistent with that view. While a specimen from South Australia would tend to drift towards New Zealand, a specimen set free upon the west coast of Australia (and the minutiæ of the present specimens agree with those of West Australian specimens) might be borne by an Indian Ocean south equatorial current round Cape Colony, whence, caught up by a north-travelling branch of the Antarctic drift, it might be carried into an Atlantic south equatorial current moving north-westwards into the Gulf of Mexico, and thence the Gulf Stream drift might bear it to the waters of the North Sea.

The journey is a long one—it has probably left its traces in the empty perisarc and the polyzoon-encrusted twig—and the chances against its successful completion are many, but it seems the only satisfactory way of accounting for the interesting occurrence of so distinct a Hydroid species off the Scottish coast.

The suggestion has been made that the specimen may have been taken accidentally, along with packing or ballast, on board some ship loading at an Australasian port, and was afterwards set free on the discharge of the ballast in the neighbourhood of Aberdeen. Such a mode of transport, however, involves so many coincidences of place that it seems highly improbable; and, besides, the condition of the specimen itself argues against the supposition, for it is difficult to believe that a number of large and fragile colonies could be first cast upon a rough sandy or shingly shore (suitable for ballast), and afterwards tossed about amongst ballast at loading and unloading, without suffering a considerable amount of damage. And yet in the present case, as the accompanying photographic reproduction (Plate III.) very clearly shows, almost all the colonies are complete, with naturally terminated stems and perfect pinnæ, upon practically every one of which, in the more mature colonies, are perched exceedingly delicate, loosely attached gonangia. The perfection of structures so fragile excludes the possibility of carriage by methods other than the most gentle, but is such as we might expect in a water-borne specimen, the sport of gently flowing oceanic currents.

After all, the mode of transport from Australasian waters to the North Sea matters little, and does not affect the main purposes of this notice, namely, to record its occurrence and to show that the species in question, although it has been found in, is not indigenous to, British waters.

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EXPLANATION OF PLATE.

Colonies of *Sertularia elongata* picked up in the North Sea (slightly reduced).

The central thicker and whiter rod is the twig over which the hydrorhiza of the colonies ramify, the whiteness being due to an encrusting polyzoon layer.

VI. *Studies on a Trypanosome found in the Alimentary Canal of* Pontobdella muricata. By MURIEL ROBERTSON, Carnegie Research Scholar in the University of Glasgow. [Plates IV.-VII.]

(Read 17th December 1906.)

In the leech, *Pontobdella muricata*, which is found parasitic on skates, and also, I believe, though less frequently, on anglers (*Lophius*), there is present a trypanosome.

M. E. Brumpt is of the opinion that this trypanosome forms part of the life-history of *T. raiæ* (*C. R. Soc. Biologie*, t. lx., 27th Jan. 1906, pp. 160-166), but he gives no details, and has, as far as I am aware, published no figures. I am inclined to support this view, in spite of the very marked difference in size and appearance between the trypanosome in the leech and *T. raiæ* (*cf.* Figs. 1 and 2 with the remaining figures), but am not yet in a position to make any definite statement in the matter. I propose in the present paper to place on record certain details regarding the part of the life-history passed in the alimentary canal of the leech. I do not claim that this is a complete account of all the phenomena found in the leech, for although a very considerable number of animals was investigated, I have had no opportunity of carrying out experimental feeding.

The material was obtained partly from the Zoological Station at Naples, and a few specimens were sent from the stations at Plymouth and Millport. The great bulk of the

material was, however, got in Rothesay Bay and the surroundings of Bute, through the courtesy of Messrs John and Thomas Thorburn, of Rothesay.

The number and condition of the trypanosomes in the alimentary canal of the leech is subject to very considerable variation, but I have only found one, out of over sixty leeches investigated, that was quite free from these parasites. The method of investigation has been as follows:—The leech is cut open along its whole length, great care being taken not to pierce the thin wall of the crop. As a matter of convenience and precaution, a small incision is first made at the anterior end and the proboscis extracted. This ensures that no possible contamination can have taken place through the bursting of the crop or the intestine. After the leech has been opened, the intestine, which is a long, thin tube extending through about the last third of the body, is either opened *in situ* or is extracted from before backwards, care being taken to nip the cut edges in a pair of forceps. The intestine is then opened by means of a needle and its contents spread out upon slides, which are either dried rapidly in air and fixed in absolute alcohol, or are fixed, while still wet, by exposure to osmic vapour, or to osmic and acetic acid vapour. The stain employed was Giemsa's modification of the Romanowsky method, or Laveran's stain. Live preparations were made by placing a drop of the fluid in the intestine on a slide, adding a drop of physiological salt solution when necessary, and immediately covering with a coverslip and sealing with vaseline. It is well, if possible, to avoid adding the salt solution, as the trypanosome remains more lively when kept in its natural medium. The dark colour of the fluid from the intestine, however, often renders observation difficult.

The parasite usually lives under these conditions from twelve to forty-eight hours, or even longer. Unfortunately, the various changes in the trypanosomes seem to follow each other very slowly; so that while much valuable information is to be obtained from the study of the living creature, the most patient observation only results in following the individual through a few usually unimportant

alterations. For instance, division which in most free Protozoa occupies at most three to four hours, and is far more often completed in less than one hour, may here be a very slow process. Thus, on several occasions, individuals in various stages of division were watched for periods of from five to seven hours, only the slightest changes being seen. The question naturally arises as to whether the conditions under which the animals are observed may not account for this retarding of the development. However, the extreme slowness of the processes of digestion make it very probable that succeeding stages follow each other more slowly than in other forms. A striking feature in the development of this trypanosome is the number of different stages that may sometimes be seen at one time in the leech. The observation of these in the living state is most instructive, as the stages are often bound together by the finest gradations. On one slide, if the material is favourable, all the transitions may be seen, from a stumpy, round organism with a short, thick, and quite stiff flagellum, to a fully developed and even very slender trypanosome. These stages are to be described later on in this paper, and they are only mentioned here as they form an interesting comment upon the present tendency to classify the trypanosomes according to the relative positions of their kinetonucleus and trophonucleus.

From the observations I have been able to make upon freshly captured *Pontobdella* in various conditions, it appears to me that the animal fills its crop at one meal, and then proceeds slowly to digest the contents without seeking food until all the blood is pretty well assimilated.

It is convenient here, for the sake of clearness, to run rapidly through the cycle of forms before describing them in detail. In the crop and the intestine of newly or comparatively newly fed leeches there are found rounded off organisms presenting both a trophonucleus and a kinetonucleus, but no locomotor apparatus (Fig. 3, Figs. 5-8, and Fig. 10). It is this form that Brumpt holds to be derived from *Trypanosoma raiæ*. These individuals, which are usually dividing fairly actively, gradually disappear entirely from the crop, and are to be seen only in the intestine. This

occurs in quite a relatively early stage of digestion. In the intestine they develop the locomotor apparatus, but persist for a considerable period in the form of a Herpetomonas-like individual (Figs. 28-41), with a short, straight flagellum, the development of which will be traced later. Division (Figs. 43-49) occurs actively amongst these stages. They vary considerably in size, and are often very small. It is to be noted that these Herpetomonas forms are very persistent, and are to be found through the whole period of infection in greater or less numbers. As time goes on, these animals develop into trypanosomes, which show much variation in size and appearance, and particularly in the position of the trophonucleus and kinetonucleus. In fact, these stages show a quite remarkable polymorphism (Figs. 16-27).

The trypanosomes are, as a rule, in the intestine, but are to be met with in the crop, and also in the proboscis, often in large numbers. At about the middle period of digestion the intestine of a well-infected animal presents a most astonishing number of forms. Herpetomonas stages in every grade of development, and trypanosomes varying from broad individuals with a relatively slow movement through space, to long, slender individuals, which move as rapidly, and after much the same fashion, as *Spirochæta anodontæ*.

Finally, towards the end of digestion, only long, slender trypanosomes and a few Herpetomonas stages, which are obviously proceeding directly to this type, are to be seen. Amongst these Herpetomonas individuals are always a number of very early stages, which may be quite small. It is these slender trypanosomes which migrate up into the proboscis, where they may become still more slender, until they are thread-like creatures, with hardly any protoplasm (Figs. 26 and 27).

At the close of digestion, that is to say, when the crop is quite empty of blood, and when the intestine shows none of the dark fluid formed by the breaking down of the blood by the digestive fluids of the leech, there may be very large numbers of the long slender trypanosomes pretty well throughout the whole leech, but very often they are still most numerous in the intestine. Besides these, there are

present the little resistent creatures in the rounded off or very early Herpetomonas stage; these may sometimes be quite minute, and seem to be able to persist through a period of starvation, and may preserve the infection without any external aid (Figs. 60-62). Thus in a freshly captured leech which showed the blood in the crop in a perfectly unaltered condition, and in which I could find no parasites of the *T. raiæ* type, there were a large number of these very minute rounded-off forms, and also the regular cycle of derivatives, *i.e.*, the Herpetomonas and trypanosome stages all in miniature, and showing signs of division. These forms proceed to grow, and may sometimes rather confuse the infection. Thus you may apparently get a persistent infection and a fresh one at the same time.

The long forms appear to degenerate and die if they remain in the leech, and this, in correlation with the presence of trypanosomes in the proboscis, suggests very strongly that this parasite is a digenetic form—the skate being, of course, the most likely vertebrate host. Still the late work of Professor Minchin and others shows how carefully this point must be gone into before one may conclude that similar flagellates occurring in a vertebrate and a blood-sucking parasite belong to the same cycle.

I propose to begin the description of the various stages of this trypanosome with the rounded-off form (Figs. 3, 5-8, and 10) possessing no locomotor apparatus. In this condition the parasite is a roughly circular organism with a conspicuous trophonucleus and a relatively large kinetonucleus.

The protoplasm of this form, which is found in the intestine and also at times in the crop, presents few features of interest; it is finely alveolar, and vacuoles are sometimes present, so also are granules.

The trophonucleus is typically composed of eight chromosomes arranged in a circle round a central karyosome. The chromosomes may be connected to the karyosome by fine rays (Figs. 3, 6, 10). While this arrangement is often diagrammatically clear, nevertheless great variations may occur. The chromosomes may be obscured, the nucleus may assume a reticulate character (Fig. 5), the number even of the chromo-

somes appears to vary; they may stand separately (Fig. 6), or be bound together by what appears to be a nuclear membrane. I am not quite clear as to whether this appearance is really always due to the presence of a membrane, or whether it may not be explained by the chromosomes becoming confluent at their outer edges. In some cases this appears to be the more probable explanation, as the connecting band may sometimes be of very considerable thickness. At anyrate, it is highly doubtful if this "membrane" can be considered homologous with that found in the nuclei of the Metazoa. This doubt is brought out very clearly, as will be seen later, by its behaviour during division.

Another variation in nuclear appearance is connected (Figs. 4, 11, 13) with the karyosome. This structure may be a small and apparently simple granule, and may even, in some specimens, be completely invisible; in others it takes the form of an easily recognisable ring, which may or may not show several thickenings. This ring-shaped karyosome is a very frequent appearance, especially in the early Herpetomonas condition (Fig. 11). At times there is a condensation of a blue staining material, probably plastin, to be seen in the region of the karyosome, this blue mass frequently bearing chromatic particles (Figs. 8, 15-19). The chromosomes, which may exceed the ordinary number, are usually joined by rays to the enlarged karyosome. Very often the space (Fig. 16) between the karyosome and the ring of chromosomes stains a pale pink with the Romanowsky stains. In this condition the nucleus bears a resemblance to the nucleus of *T. raiæ* and to that of many free-living flagellates.

I wish here to remark that the word karyosome is used under protest; this term is used in Cytological literature to designate two different orders of structures. Strictly speaking, a karyosome is a simple condensation of nuclear, or, better, chromatic material; it is, in fact, a chromatic nucleolus. In Protozoan literature it is applied impartially to a number of doubtfully homologous structures, most of which are of a complex nature, and not justly comparable to a metazoan karyosome at all.

The kinetonucleus, which is usually fairly large in size, is

highly refractive, and takes the stain very deeply, so that it is very difficult to get a clear view of its detailed structure. In shape it is oblong, and very often presents the appearance of a rod (Fig. 12) split along its longitudinal axis. It is not a perfectly simple structure, but appears to be made up of several chromatic elements. This body is, on the whole, pretty constant in its appearance, much more so than the similar organ in *Trypanoplasma borrelli* as described by Keysselitz,[1] still even here variations occur. Sometimes (Fig. 6 and Fig. 54) the kinetonucleus is circular and gives indication of a structure not unlike that of the trophonucleus: it has, however, been so far impossible to count the number of chromatic thickenings, as the details are always very obscure (Figs. 3-13, etc.). Occasionally there may be a certain amount of a substance taking on a blue colour in the kinetonucleus. Sometimes, too, a little granule may be detected in the centre of the kinetonucleus, as in Figs. 34, 35, but these points are very inconstant and very difficult to make out: they are most obvious when the kinetonucleus is about to divide. Of course, in questions of such fine detail, adventitious appearances, due to difference in staining, are very apt to cause confusion.

Another modification occurs through the deeply staining material of the kinetonucleus becoming concentrated into two or more little aggregations; these stain almost black, while the remaining parts take on a homogeneous bright red with the Romanowsky stains (Fig. 7). This appearance is not at all frequently met with, and has probably to do with the physiological relation between the kinetonucleus and the protoplasm. Keysselitz observed an exactly similar phenomenon in the kinetonucleus of *T. borrelli*.

There appear, however, to be very generally two substances present in the kinetonucleus, one of which stains more deeply than the other. What I have described as the split-rod appearance of the kinetonucleus is a very common feature in the larger rounded off individuals and in the forms immediately derived from them. It is curiously suggestive of a double or composite structure, but I am at a loss for an

[1] *Arch. f. Protistenkunde*, Bd. vii., 1906.

explanation of the phenomenon. It does not appear to be due to a refraction effect (Fig. 12, etc.).

Before leaving the kinetonucleus, there is another cell structure connected with it to be considered, although it is only very rarely visible in the rounded-off state. This is a very minute granule (Figs. 9 and 54) which seems to come out of the kinetonucleus, and to be bound to it by a very delicate thread. It usually, in the trypanosome and the intermediate flagellate stage, lies posterior to the kinetonucleus, often at the extreme posterior tip of the body. It is a very delicate and illusive structure, and difficult to see even when present; it is, however, quite a definite cell element, and divides at division of the individual, as can be seen in Fig. 54. This little basal granule has, possibly, to do with the anchoring of the kinetonucleus. Similar granules have been described in *H. muscæ domesticæ* and also in many trypanosomes.

The phenomenon of chromidium formation is found at times in these rounded-off forms, but as the significance of the process is still obscure, I do not propose to go into the question at the present time. It may be noted that individuals with chromidial nuclei are to be found in small numbers at all stages of development (Fig. 7).

Division.—Division occurs pretty freely among the rounded-off forms, a circumstance which is indicated by the number of individuals which present two nuclei and two kinetonuclei. But it will be better to consider this process as a whole later, after the different forms have been described.

The nuclear features mentioned in the foregoing account as occurring in the rounded-off forms are, as will be seen from the figures, found in all the stages of development. The modification which is seen in the trophonucleus of the long slender type of trypanosome will be noted when this form is described (Fig. 25).

Among the rounded-off individuals just about the time when the flagellar apparatus begins to develop, there are found some very large forms, usually oval or pear-shaped. They have a very considerable amount of protoplasm, and the nucleus, which is usually large and rather irregular,

frequently shows a very large karyosome, which contains a quantity of a plastin-like substance. It is from these forms (Fig. 15, *a*) that the large broad trypanosomes are later developed. I am ignorant as to their earlier history, but am inclined to imagine that they arise simply by growth from the ordinary smaller forms.

Development of the Flagellum.

From the rounded forms, which, it will be remembered, have a well-defined trophonucleus and a large, persistent kinetonucleus, there arises a flagellate, which is in the condition of a Crithidia or Herpetomonas as regards its flagellar relations. I propose to call this the crithidial stage, to distinguish it from the trypanosome condition.

There is one remarkable feature in the stage at which the motor organ arises, namely, that this is usually, so far as my experience goes, essentially a division stage. Two flagella arise side by side from two little structures, and division is apparently the usual, if not the invariable, sequel (Figs 28-41). This part of the cycle will be made most clear by a description of the various stages. One of the first stages (I propose to call this stage 3, Figs. 30 and 31) consists of a slightly oval individual, with an elongated but not yet obviously divided kinetonucleus. In front of the kinetonucleus, and parallel to its long axis, a fine but quite distinct red-staining bar may be distinguished. This bar is bound to the kinetonucleus by four fine red staining threads (Figs. 30 and 34). It may be noted that the red bar and the connecting threads are very constant features. Between the bar and the (anterior) margin of the protoplasm are two slightly irregular spindle or rod-shaped bodies lying close beside each other. I propose, for the sake of convenience, to call these the preflagellar bodies—there is as yet no sign of the flagella themselves. One has no very definite explanation to offer as to why these structures should so generally arise in this double condition. There is, however, a suggestion, which I advance quite tentatively, that this double origin of the flagellar apparatus may be due to a phylogenetic

connection with some such form as *Herpetomonas muscæ domesticæ*, where the flagellum persists as a double structure, *i.e.*, is composed of two flagella joined by a narrow membrane.[1] In the form at present being considered, it operates simply as a precocious division. Stage 3 has been described first, as it is a very definite condition and explains the earlier development. Stages 1 and 2 of the development of the preflagellar bodies appear to be represented by Figs. 28 and 29.[2] Fig. 28 (stage 1) shows a longitudinal division having taken place in the kinetonucleus; this, it will be seen, has occurred in the opposite direction from the ordinary division of this body, which is transverse. One is, however, prepared for this by the appearance of what I have called the cross-bar.

In stage 2 (Fig. 29) the segment of the kinetonucleus farther away from the trophonucleus has taken the form of an oblong body composed of two thick little vertical bodies. These are joined by two horizontal cross-bars. I consider this structure to be the early stage of the preflagellar body, and interpret it as presenting a so far incomplete transverse division, the method in some points closely resembling the normal division of the kinetonucleus to be described later.

I am not clear as to when exactly the anterior of the horizontal cross-bars shown in Fig. 29 disappears. The two vertical bodies (arising from the distal segment of the original kinetonucleus) each grow out into a little rod or spindle-shaped bundle of fibres (Figs. 30, 31), which may perhaps be interpreted morphologically as mitotic figures. The fibrillar character of the finally developed flagellum may sometimes be most strikingly demonstrated in crushed or slightly macerated specimens.

The next stage is represented in Fig. 32, and shows the kinetonucleus just divided. The red cross-bar has altered in appearance, and now presents two little thickenings at its central part. The preflagellar bodies are beginning to move

[1] See Prowazek, "Die Entwicklung von Herpetomonas," *Arb. a. d. kaiserlichen Gesundheitsamte*, Bd. xv. Heft. 3, 1904.

[2] Stages 1 and 2 are very difficult to find; they are probably passed through more rapidly than the later stages.

apart, and show each a connection to the kinetonuclei, not only by means of the modified cross-bar, but, in addition, each by a fine red line to the distal portions of the kinetonuclei. These last-mentioned lines appear to me to correspond to the outer pair of the four lines described above as joining the cross-bar in the earlier stage (Fig. 31) to the kinetonucleus.

In a later stage the kinetonuclei have moved apart and the flagella are already projecting from the spindle-shaped preflagellar bodies (Fig. 33). They grow out as fairly thick prolongations, and are in the living state at first very stiff and non-motile; they do not invariably keep time, one flagellum sometimes being considerably in advance of the other. If the relative positions of the kinetonuclei and the flagellar spindles is observed in Figs. 35 and 31, it will be seen that the separation of the former, as shown in Fig. 35, has brought about a rotation in the position of the spindles, so that now their distal ends point towards each other. The spindles, it is now seen, are still bound to the kinetonucleus by two slender threads (Fig. 36, etc.). (These threads do not show, as a matter of fact, in Fig. 35, but are of quite definite and constant structure, though very delicate.) Fig. 47 illustrates this point more clearly. It is about this stage, *i.e.*, when the preflagellar bodies are removed from each other, that the red cross-bar is no longer to be distinguished.

Division of the trophonucleus and protoplasm now take place. The preflagellar bodies still persist, and it is at this stage, in very delicately stained individuals, that a certain amount of detail may be seen in these structures. Figs. 38 and 39 illustrate this period in the development, a review of the proximal part of the flagellum in these individuals suggesting that the flagellum has grown out from the central part of the preflagellar spindles. It is impossible, however, to be sure of a point of this kind where the detail is so extraordinarily minute.

The body of the animal now begins to lengthen out, and the kinetonucleus gradually moves back behind the trophonucleus, drawing the flagellum with it. The preflagellar

body is distinguishable through a very considerable number of stages, and is finally represented by a little red bulge (Figs. 41, 42 *a* and *b*). The two fine red strands forming the junction between the preflagellar body and the kinetonucleus are exceedingly persistent, and can sometimes be seen in the fully developed adult trypanosome (Figs. 38-42 *b*).

Slight variations in the development of the flagellum occur, but they are of a very insignificant character. Occasionally the preflagellar bodies appear to be thinner (Fig. 33), and assume the flagellar appearance at an earlier stage.

This has, I think, occasionally to do with the stain, which may only pick out part of the apparatus. The demonstration of these preflagellar bodies is often a very difficult matter, on far the larger number of otherwise quite satisfactory preparations they appear simply as a little white patch in the protoplasm at the anterior end of the animal. Workers studying trypanosomes are familiar with the difficulty frequently experienced in getting the flagella to take the stain. The preflagellar bodies show an even greater obstinacy and capriciousness in this matter. Very satisfactory preparations may, however, be obtained by the ordinary Laveran and Giemsa procedures.

Briefly to sum up this question: The flagella appear to be developed from a pair of arrested mitotic figures developed out of the distal of the two segments into which the original kinetonucleus divides.

At what I have called the "Herpetomonas or Crithidial stage," the kinetonucleus lies in front of the trophonucleus, and the flagellum projects straight out. Before division takes place, two flagella may be distinctly seen, both in the living condition and in stained preparations. The movement of the live Herpetomonas-like forms with one flagellum is interesting. The flagellum is lashed about rather stiffly, and the body of the creature, which shows none of the rippling motion characteristic of so many trypanosomes, is drawn after it. In fact, a less trypanosome-like movement could hardly be imagined. It is most fascinating to observe the fine gradations in external shape and in the method of

locomotion that are to be seen on a single slide of live material where this process is going on. As the animal assumes the trypanosome condition by the lengthening of the body and the migration posteriorwards of the kinetonucleus, the creature as a whole becomes more lissom, and more of the movement is executed by the flexion of the body and less by the lashing of the flagellum. *Cf.* Figs. 39-42 *b*.

In the Crithidial stages the arrangement of the granules is worthy of notice, in so far as these, when present, may lie in either the flagellate or the non-flagellate part of the creature pretty well indifferently, though they are perhaps more frequent in the non-flagellate end.

Even in the fully-developed trypanosome, the granules may sometimes lie posterior not only to the trophonucleus but also to the kinetonucleus. In other cases they are pretty evenly divided throughout the whole creature, or may be in the flagellate end. It may be mentioned in passing that granules are of very varied occurrence in these trypanosomes.

The development which has just been traced seems to me to be a strong argument against the division of the Hæmoflagellates suggested by Dr H. M. Woodcock in the *Quarterly Journal of Microscopical Science*, April and June 1906, into *Monadina* and *Heteromastigina*, a division based on the conception that the anterior flagellate end of the Herpetomonadine forms corresponds to the posterior non-flagellate end of the trypanosomes. Dr Woodcock thus derives the trypanosomes not from a Herpetomonad ancestor by the migration posteriorwards of the kinetonucleus, but from a bi-flagellate form of the type of *Trypanoplasma borrelli* by the loss of the anterior flagellum. He therefore separates *Trypanomorpha noctuæ* from all the other trypanosomes. I do not wish here to enter into the vexed question of the ancestry of Hæmoflagellates. It would be rash, as well as futile, to discuss this point at the present time, and this is more especially true where such a phylogenetically eclectic form as a trypanosome is concerned. I would only wish to observe that while trypanosomes have features reminiscent

at times of both Hæmogregarines and Spirochætes, there is also, as the above series of stages show, a very strong Herpetomonad affinity. I also wish to point out that the position in the body of the protoplasmic inclusion upon which Dr Woodcock is inclined to lay so much stress, can hardly be held, in the light of these observations, to be of serious morphological importance.

Trypanosome Stages.

Amongst the "typical" trypanosomes, that is, those individuals which have their kinetonuclei at or towards the posterior end of the body, and which possess the usual locomotor apparatus, two main types may be distinguished. The most striking of these is a long, slender trypanosome (Fig. 25), with a large kinetonucleus lying occasionally parallel to the longitudinal axis of the body, instead of at right angles to it, as in the Herpetomonas forms from which it develops (Figs. 39-42 *b*). At the edge of the usually very narrow membrane, there runs the flagellum, which projects to a varying distance beyond the protoplasmic body, but the free part is, as a rule, not very long.

The nucleus has become modified; the chromatin is no longer disposed in the familiar circle enclosing the central karyosome, but forms a number of transverse rods: the karyosome is often no longer to be distinguished. The different stages by which this form is developed can, upon favourable material, be traced with the utmost clearness. The process is illustrated in Figs. 38-42 *b*. The difference in the appearance of the trophonucleus is brought about by the narrowing and lengthening out of the structure, the chromosomes from the opposite sides being thus brought into contact with each other across the middle line. This point is shown in Figs. 22, 23, 24, 55, 59, etc.

In the live state, this slender trypanosome moves very rapidly through space, the motion being executed much more by the whole body and less by the undulating membrane than, for instance, in the case of the ordinary mammalian trypanosomes. The body also gives the impres-

sion of a much greater elasticity, some of the movements, as I have stated, resembling those of the larger Spirochætes, as *Sp. anodontæ.* Thus it may execute a figure 8 and other complicated movements repeatedly while remaining on the same spot. It may sometimes be seen with one end curled up into a circle, or may even fold itself in two like a penknife.

At a later stage of the digestion, a still more slender, practically thread-like form is developed, which agrees with the last in all points except that it is smaller and much more slender, and the trophonucleus has a tendency to lie nearer to the kinetonucleus. It is this form which is found in the proboscis (Figs. 26 and 27).

The other main type is a relatively very broad organism, with sometimes a relatively smaller kinetonucleus. The flagellum is, however, usually fairly long. The trophonucleus is often of the type which presents the large blue staining karyosome with scattered red granules (Figs. 15-19).

Typical nuclei with eight chromosomes and a small karyosome are also met with, and in some specimens the nucleus has a rather irregular and scattered appearance. The protoplasm of this form stains deeply, sometimes with a pinkish tinge. It moves fairly actively, but not very rapidly through space.

These forms, *i.e.*, the long, slender trypanosomes and the broad form just described, are joined up by a number of intermediate stages (Figs. 20-24).

One is naturally led to suspect a sexual differentiation in these forms. I hesitate, however, to assert that the broad individuals are female forms and the slim individuals male forms, and that for several reasons.

Firstly, I have never yet observed conjugation; further, although this difference in appearance is generally held to indicate a sexual differentiation, there is in this trypanosome, so far as my experience goes, no evidence that can be held to directly support such an hypothesis. Moreover, the number of intermediate stages, and the great variability in size of the broad individuals, suggests the possibility of this difference in appearance being a physiological question,

due, perhaps, to nutrition—this being apparently borne out by the fact that they are always developed at the middle period of digestion, when the fluid in the intestine is probably most rich in nutritive material. No such table of sizes as that drawn up for *T. brucei* and *T. gambiense,* in Koch's interesting paper[1] for male and female forms, could be made in the case of the trypanosome in *Pontobdella.* One feels that it is dangerous to settle a point of this kind from analogy with other forms, and at the present state of our knowledge it is better to leave the matter unprejudiced. Of course, one may here be dealing with a continuous series of forms of which the extreme members might be considered respectively male and female, and we might possibly here be confronted with a transition between Isogamy and Heterogamy or—what is perhaps more probable—with a condition of affairs in which only the extreme members of the series proceed to conjugate: that is to say, only those individuals in which the male and female differentiations are expressed actually conjugate. Speculation is not, however, of much use until more of the facts are known.

The only remaining forms to be dealt with are the minute creatures which persist, and which appear to be capable of preserving, the infection in the leech.

These do not call for special description, as they are simply, as far as I can see, miniature replicas of the larger forms, and seem to grow into small, rather thin trypanosomes, which increase in dimensions as digestion goes on (Figs. 60-63).

There is one phenomenon still to be mentioned before passing to the consideration of division, namely, the tendency of isolated trypanosomes, in almost all the different stages, to return at times to the rounded-off state. I do not know what exactly brings this about. The result, however, is sometimes to very much heighten the extraordinary variety of external shape to be observed in a strong infection during the middle period of digestion.

[1] Koch, "Über die Unterscheidung der Trypanosomenarten," *Sitzber. der k. pr. Akad. d. Wiss,* 16th-23th Nov. 1905, page 961.

The figures, which have had to be restricted from considerations of expense in reproduction, hardly do justice to the polymorphism of the trypanosomes (Figs. 14-27).

Division.

Division occurs with greater or less activity in every stage of the life-cycle. The only form in which this process has not been observed is the thread-like individual found in the proboscis of the leech. It is in the early Herpetomonas condition, however, that division is most frequent, and it is in these forms that the nuclear detail has been most clearly made out. The type of division here to be observed is a primitive kind of mitosis.

In the Herpetomonas stage before division, the nucleus, as a general rule, presents eight well-defined chromosomes, joined at their outer edges by the nuclear "membrane" or outer chromatic ring, which is particularly distinct at this stage (Figs. 4 and 11). The central karyosome is in the shape of a fairly large ring, usually enclosing a blue staining space. Occasionally a tiny granule may be seen in the centre of the ring, but this is a rather rare and inconstant feature; occasionally, also, the ring-shaped karyosome may bear thickenings. In the very earliest stages the nuclear pictures are a little obscure, but the following points are to be made out. The nuclear "membrane" does not break down at the beginning of mitosis; the whole nucleus, however, becomes slightly flattened into an oval, whose long axis is at right angles to the axis of the first part of division. The karyosome also becomes oval in the same direction, and increases in size, although it usually becomes less definite. Presently it is seen (Fig. 43) to have split longitudinally into two irregular bands, or more often into two series of little masses, whose outline is not by any means always quite clearly defined. Between these two sets there stretches a series of fibres which are, at first, a little irregular and rather thick. As the nuclear membrane has, as a general rule, not yet become much disturbed, the nucleus presents an oddly double appearance (Fig. 43).

As division proceeds, the fibres which arise in the region occupied by the karyosome become very distinct, and seem (Figs. 43*a*-45) to stretch through the whole of either part of the dividing nucleus, the halves of which become, as it were, pushed apart. The nuclear membrane becomes less distinct, and appears to divide across at the equator, and the chromosomes usually become quite confused. In about the middle stage of division, it is to be noted that the fibres of the mitotic figures are spread out at either (Fig. 46) nucleus over quite a wide space—usually the whole width of the nucleus—but are narrowed down towards the centre. The narrowing of the fibres creeps, as it were, from the equator or centre of the mitotic figure towards either nucleus, and it is now found that they form an extraordinarily well-defined bar (Fig. 47), whose attachment at the nuclear ends is, curiously enough, connected with the reintegrating "membrane." This point is exceedingly clear in some cases.

During the process of division there often, though not invariably, appears to be a rotation of the axis of the whole division figure through an angle of 90°. A glance at Figs. 45 and 46 makes this very obvious.

The trophonuclei gradually become completely reconstructed, and individuals are to be found showing two perfectly definite nuclei with eight chromosomes and the ring karyosome and a well-defined membrane, the two bound together by a very straight and extraordinarily clear band of fibres. The fibres may sometimes be so persistent as to stretch between the nuclei after the protoplasm between them has divided, *cf.* Fig. 48. There is an interesting resemblance between this bar and the flagellum, both as regards its development and its optical appearance.

Ultimately the band of fibres disappears, but it is to be noted that it is not included in the nuclei, but vanishes in the protoplasm.

This form of division is a simple mitosis. An achromatic nuclear figure is very definitely formed, and may, I think, in some measure be compared to the axial fibres of more advanced types. There is no equatorial plate formed, nor

any division of individual chromosomes, and, correlated with this, there is no trace of mantle fibres.

The karyosome appears to exercise certain kinetic or centrosomal functions, but is not, in my opinion, responsible for the whole of the mitotic fibre apparatus. It is not a case of an amitotic division of the nucleolocentrosome such as Keuten has described in Euglena, bringing about a division of the surrounding chromatin; but rather a set of fibres arising much as in the case of the metazoan mitosis, only here the process occurs inside instead of outside the nucleus.

In the parasite under discussion, it is difficult to make any statement as to whether the centrosomal functions are concentrated into a definite granule, as in the case of *Trypanomorpha noctuæ,* or are more or less diffusely present in the karyosome. The granule occasionally found within this structure is too indefinite and inconstant to be able to make any statement concerning it.

The division of the kinetonucleus, which is always a transverse one at first sight, suggests amitosis. Further study, however, shows that there is here also a simple kind of mitosis, although the details are extraordinarily obscure. The kinetonucleus, as already stated, is composed of several elements, and it appears to contain two substances, one of which stains very much more deeply with the red element of the Romanowsky stain than the other (Figs. 31-34).

The earliest sign of division is that the deep staining chromatic substance becomes arranged in two little parallel rods, one at either side of the kinetonucleus. Each of these bears the appearance of being slightly split transversely to the axis of the little rod (Figs. 33, 34, 43, and 49). These two rods appear to be connected along the top and bottom by two slender vertical bars, thus the oblong shape of the kinetonucleus is still preserved. The remainder of the structure is filled with a brighter red substance. There then appears to be an increase in the length of the two dark staining rods, until these are each as long as the ordinary kinetonucleus. Exactly how this is effected I do not know. Presently the two new blepharoplasts move slightly apart,

and the paler red substance forms a set of fine (Figs. 43*a* and 44) fibres which may connect the two daughter structures for some time. This band of fibres can sometimes be traced after it has broken in the centre, and may every now and then produce rather confusing appearances. It ultimately disappears in the protoplasm. I am inclined to think that the paler substance which, as it were, bathes the darker chromatic elements, becomes fibrillar, and effects division in much the same way that the central fibres do in the case of the trophonucleus. In the blepharoplast, of course, the process seems to approach nearer to amitosis.

Slight variations occur both in the division of the trophonucleus and the kinetonucleus, but they are not sufficiently important to be gone into here. The division of the two nuclear elements in all stages is fairly independent of each other.

The nuclear division of the other forms assumed by this parasite is peculiarly difficult to obtain in complete series, although specimens with two nuclei are relatively quite common. The chief variation, as far as I can see, is that in most of the trypanosome forms the division figure disappears much more rapidly, and while the nuclei are still often quite close to each other.

I am ignorant as to how division occurs in the slender trypanosome, with the chromatin arranged in bars as in Figs. 25-27.

The appearances presented by the various forms during the later stages of division, after the mitosis of the tropho- and kinetonucleus, are of considerable interest, especially as they frequently simulate conjugation. I propose, therefore, to describe the more striking cases.

To begin with the early Herpetomonas forms, the division of the preflagellar bodies and their relation to the kinetonuclei has already been described. As regards the division of the protoplasm, the greatest possible variation is to be found.

Thus division may occur from the non-blepharoplast end (*i.e.*, the posterior end of the Herpetomonas stage), as in Fig. 48, or from the blepharoplast end (Fig. 36). The two creatures

may separate quite simply while their long axes are parallel to each other, or may turn out from each other while still joined by their posterior ends till the long axes form a single straight line (Fig. 37). Or, again, a rotation of the two nuclei and the two kinetonuclei may occur within the protoplasm before any sign of division of the cell-body can be distinguished. A strange appearance may sometimes be presented by forms in which the protoplasm is only partially divided, but where one of the developing flagella has got ahead of the other, thus giving the impression of two animals at different stages. Very misleading forms may be found, in which the tropho-nuclei are proceeding to divide again before the division of the protoplasm (Fig. 49). These figures—and ones where there are four nuclei and two blepharoplasts, as Fig. 50—are very suggestive of conjugation, and might be interpreted as nuclei undergoing the last reduction division before fusion. One might with great ease fall into this error in material where these appearances crop up singly. If, however, a sufficient number of specimens are reviewed, it becomes abundantly clear that they are not due to conjugation, but really illustrate multiple division. Fig. 51 shows obvious division into four, and affords an explanation of the four nuclei in Fig. 50. I may here add that division into three is a not infrequent appearance in (Figs. 53 and 52) material where active multiplication is going on. The protoplasmic features in all these stages, and also in those about to be described, can be most beautifully made out in the living specimen, although no very striking changes can be observed on the one individual. The last stages, *i.e.*, the final separation of the daughter individuals, was, however, followed in the live state. The division of the trypanosome stage, which may upon occasions be quite unequal, presents some features of interest.

The blepharoplast and flagellum usually divide before the trophonucleus, but there is no sort of regularity in their relations. I have not been able to observe the division of the flagellum, and cannot say anything as to whether it really splits or is re-formed, but I incline towards the former view. The usual point of departure for division of the

protoplasm is from a creature with two trophonuclei, one behind the other, and with two kinetonuclei, one at each side and at the same level. From each of these there passes forwards a flagellum and its undulating membrane. The protoplasm now begins to split from the flagellum end posteriorwards. Fig. 54 illustrates a pretty late stage, and agrees with division as generally described in trypanosomes. It is interesting to note that here the little basal granule can be distinguished also about to divide, and bound to each kinetonucleus by a very slender thread. The trophonuclei, it will be seen, are beginning to assume the cross-barred condition already described.

This creature proceeds to split up further until it is in a straight line, kinetonucleus to kinetonucleus in the ordinary way. While this is the typical method, many interesting variations occur with such frequency that they cannot be neglected as abnormal appearances. During division the animal is in constant and often very active movement, and this is, I think, a potent factor in determining some of the points. Fully developed trypanosomes are met with where only the anterior third or so of the protoplasm has divided, and it may sometimes be noted that one or both of the two trophonuclei have slipped through between the blepharoplasts, so that, at a later stage, such as Fig. 56, trophonuclei and kinetonuclei are arranged alternately. When division is complete, one finds that there will be one trypanosome with the nucleus at or near the extreme posterior tip of the body, and with the blepharoplast immediately in front of it, and another with the usual arrangement, *i.e.*, the blepharoplast posterior to the trophonucleus. This method of division explains trypanosomes in the condition of Fig. 57, and specimens are often found with the trophonucleus in a still more posterior position. Fig. 55 shows an even greater difference between the daughter individuals.

Fig. 59 is an interesting creature, in that it shows that the nuclei of the daughter animals differ considerably in appearance, and also indicates that one individual will most probably have a much larger share of the protoplasm than the other. This specimen also offers something of an explanation of

cases such as Fig. 58, where the one product of division is a broad, short individual much richer in protoplasm than the other. These specimens, when seen alive, are most extraordinarily suggestive of the conjugation of a male and female gamete, and many hours were spent in observing these creatures in the live state in the hope of seeing them fuse completely together. This, however, never happened, and the study of the stained specimens finally settled the question most convincingly in favour of division.

I have drawn attention to these points because one feels that conjugation among the Protozoa is such an interesting and important question, and at the same time of such great difficulty, that more especial care must be exercised lest faults in observation confuse a phenomenon whose meaning is already sufficiently obscure.

It is impossible not to observe that the tendency of modern protozoan research is to interpret appearances as conjugation upon rather slender evidence, and this criticism is, perhaps, more particularly applicable to the literature dealing with the typical trypanosomes. On the other hand, one is led to expect, from theoretical consideration, that this process must take place at some point of the life-cycle.

I should like to record in passing that a Hæmogregarine, closely resembling *Hæmogregarina delagei*, Lav. and Mesn., parasitic in the red corpuscles of the skate, has occasionally been met with in the intestine of the leech. The life-cycle of this form has not as yet been traced.

The work here recorded was done in the Zoological Laboratory of the University of Glasgow under the direction of Professor J. Graham Kerr, whom I have to thank for many kind suggestions and much valuable advice.

My thanks are due to the Carnegie Trust for providing me with additional microscopical apparatus, which was of great assistance in carrying out the research, and, further, for defraying the expense of the necessary illustrations.

Description of Figures.

The figures, with the exception of Figs. 1, 2, 3, 5, 7, 9, 10, 12, 13, were drawn under the 2 mm. immersion by Zeiss (long tube) and eyepiece No. 27. The above-mentioned exceptions were drawn under the 2 mm. immersion by Zeiss (short tube) and eyepiece No. 18. The drawings were all made with the camera Lucida.

Figs. 1 and 2. *Trypanosoma raiæ*, from the blood of the skate.

Figs. 3-63. Illustrate stages of the trypanosome found in the alimentary tract of the leech *Pontobdella muricata.*

Fig. 3. Rounded-off stage, showing nucleus with eight chromosomes and a central karyosome and the kinetonucleus. No locomotor apparatus present.

Fig. 4 shows trophonucleus with karyosome in shape of a ring. In front of the kinetonucleus the slender red body visible is a very early stage of the locomotor apparatus.

Fig. 5 shows reticulate trophonucleus.

Fig. 6. Rounded-off stage.

Fig. 7. Chromidial condition of rounded-off stage; the condensation of the dark material in the kinetonucleus into two small dark bodies can be seen in this individual.

Fig. 8. Ring-shaped karyosome, with condensation of plastin, can be seen in the trophonucleus.

Fig. 9. Stage, with reticulate trophonucleus, showing basal granule attached to the kinetonucleus.

Fig. 10. Two very typical rounded-off individuals.

Fig. 11. Young trypanosome, showing trophonucleus with ring-shaped karyosome.

Fig. 12. Spear-headed trypanosome, showing reticulate nucleus and the split rod appearance of the kinetonucleus.

Fig. 13. Stage, with ring karyosome, enclosing a central granule.

Fig. 14. Slender trypanosome.

Fig. 15. Large broad form, fixed with osmic acid vapour. The trophonucleus shows the karyosome, with condensation of plastin; *cf.* trophonucleus with that of Figs. 16 and 17.

Fig. 15*a*. Large form. Note the irregular and scattered character of the trophonucleus.

Fig. 15*b*. Smallish round trypanosome to illustrate modification in external shape.

Figs. 16–27 illustrate some of the appearances presented by the trypanosomes.

Fig. 16. Large broad form, possibly a female form. Note the trophonucleus, with blue staining karyosome; also the increased number of chromatic thickenings at the periphery of the nucleus, and the pink area surrounding the karyosome.

Figs. 17, 18, 19. Smaller broad forms, to show variation in shape and appearance.

Figs. 20–23. Intermediate forms between Fig. 16 and Fig. 25.

Fig 24. Trypanosome to show variation in shape.

Fig. 25. Long slender trypanosome ; possibly male form.

Figs. 26 and 27. Slender trypanosomes from the proboscis of the leech.

Figs. 28–42*b*. Development of locomotor apparatus.

Fig. 28. Rounded-off form, with segmenting kinetonucleus. Note the division is a longitudinal one (Stage 1).

Fig. 29. The distal segment of the kinetonucleus shows signs of a transverse division (Stage 2).

Fig. 30. The distal segment of the kinetonucleus has grown out to form the two preflagellar bodies. Note their attachment to the kinetonucleus, and also the appearance of the kinetonucleus, which is preparing for division (Stage 3).

Fig. 31. Much about the same stage as 30, but the kinetonucleus is elongated preparatory to division. The cross-bar at the base of the preflagellar bodies is very definite in this figure.

Fig. 32. Division of the kinetonucleus. This has occasioned the separating of the proximal ends of the preflagellar bodies The cross-bar is represented by the two little red bodies towards the left of the two daughter kinetonuclei.

Figs. 33 and 34 illustrate the out-growth of the flagella. They both show the red cross-bar.

Fig. 35. The kinetonucleus is divided, and the preflagellar bodies are separated from each other.

Figs. 36 and 37 show division of the protoplasm.

Fig. 38 shows later stage. The preflagellar body, both in this and in Fig. 39, suggest that the flagellum has grown out from the axial part of the preflagellar body.

Figs. 39–42*b* show the development of the Crithidial or Herpetomonas-like stage nto the trypanosome. Note the quite indifferent distribution of the protoplasmic inclusions.

Figs. 43–49. Division of the trophonucleus.

Fig. 43. Early stage of division. The plane of division of the trophonucleus is here parallel to the longitudinal axis of the body. In the centre of the nucleus the two sets of chromatic particles, derived apparently from the karyosome, are to be

seen joined by an irregular arrangement of red staining strands. The resting state before division is illustrated by Fig. 4.

Fig. 43*a*. Rather later stage. Note the development of the mitotic fibre apparatus, and the pushing apart of the two halves of the nucleus. This figure illustrates the division of the kinetonucleus. I am not quite clear about the red strand passing back from the kinetonucleus to the posterior edge of the protoplasm, but think it has to do, very probably, with the basal granule.

Figs. 44, 44*a*, and 45. Further stages of division.

Fig. 46 shows the middle stage of division; the fibres are beginning to narrow down at the centre.

Fig. 47 shows the bar of fibres joining the two reconstructed trophonuclei; it will be seen that this bar is connected apparently with the "membrane" of the nucleus. The preflagellar bodies, and their connection with the kinetonuclei, are well shown in this figure.

Fig. 48 shows the bar of mitotic fibres joining the nuclei, although the protoplasm is already divided.

Fig. 49 shows precocious division of the two trophonuclei before the protoplasm is divided.

Fig. 50. Individual, with four trophonuclei and two kinetonuclei.

Fig. 51. Division into four.

Fig. 52. Division into three.

Fig. 53. Division into three; here the trophonuclei have divided, but the kinetonucleus is not yet divided.

Fig. 54. Late stage of division of the trypanosome. This shows the division of the basal granule.

Fig. 55. Late stage of division. Note the difference between the two daughter individuals and the position of the trophonuclei and kinetonuclei.

Fig. 56. Note alternate position of the trophonuclei and the kinetonuclei.

Fig. 57. Product of such a division as that shown in Fig. 56.

Fig. 58. Division in which one of the individuals is markedly broader than the other, the nucleus of the broad individual is slightly disorganised; this is a purely accidental occurrence.

Fig. 59. Unequal division. Note the difference in appearance of the two trophonuclei.

Figs. 60–62. Small persistent forms, which seem capable of surviving through a period of hunger, and reinfecting the leech.

Fig. 63. Young trypanosome developed from these small forms.

VII. *The Myriapods (Centipedes and Millipedes) of the Forth Area.* By WILLIAM EVANS, F.R.S.E.

(Continued from Vol. XVI. p. 414.)

Class SYMPHYLA.

Family SCOLOPENDRELLIDÆ.

Scolopendrella immaculata, Newp.

Scutigerella immaculata (Newp.).[1]

This deeply interesting little animal is widely distributed and fairly common in our area. I frequently come across an example or two under stones, pieces of wood, etc., which have lain for some length of time on slightly damp ground. Occasionally it has occurred in an ants' nest under a stone. First recorded from Scotland by me in 1900 (12*a*), and from Ireland by Carpenter (10). England, Germany, Norway, etc.

Local data.—Dreghorn and Hillend (foot of Pentland Hills), March ! Carpenter; Bush, near Roslin, Oct.; Arthur's Seat, in ants' nest, and near Balerno (half dozen), April 1901, ! P.; Allermuir Glen, Pentlands, one, March 1902; near Kirknewton, March and April 1905, and a dozen, 31st March 1906; Bonnytoun Hills, between Linlithgow and Bo'ness, several, Aug. 1901; Dollar, two, April 1897; Kelty Glen, Callander, a few, April 1900; Pettycur, April 1899; Culross, two, April 1901; West Wemyss, Fife, a few, in ants' nests under stones, April 1906. Have also found it in the Tay area, at Muthill, Sept. 1901.

Class DIPLOPODA (Millipedes).

Family POLYXENIDÆ.

Polyxenus lagurus (Linn.).

Apparently very local in the district, but fairly plentiful where present. I had often looked for this curious little creature (length only about 3 mm.) without success in the usual habitats, namely, on old fences, and under bark on dead trees, and in the end found it quite accidentally when searching for beetles at the roots of *Plantago maritima* on the

[1] Ryder's genus *Scutigerella*, 1882, was not regarded by Latzel (Die Myriopoden, etc., ii. p. 11) as of more than subgeneric value; but *cf.* Hansen, *Quart. Jour. Micros. Sci.*, xlvii. 1903.

Haddingtonshire coast. Gibson-Carmichael (7) has recorded it from Peeblesshire. New Forest (Pocock, 14) and elsewhere in south of England. In Ireland it has been found in Phœnix Park (9) and Lambay Island, Dublin, where Prof. Carpenter tells me it is common. Knowing only the Phœnix Park record, and that imperfectly, Sinclair (15) formed the erroneous opinion that this species occurs in the British Islands merely as a foreign importation. It occurs in Norway, etc.

Local data.—Sea-braes east of North Berwick, Haddingtonshire, plentiful about roots of *Plantago maritima*, 27th May 1905 (specimen shown to Carpenter for authentication).

Family **GLOMERIDÆ.**

Glomeris marginata (Villers).

Julus oniscoides, Stewart's List of Edinburgh Insects (1).
Glomeris limbata, Latr., Gibson-Carmichael's List (7), and Boyd's (13).

The pill-millipede, to use the recognised English name for this pretty species, though probably widely distributed in the district, is by no means common. By the uninitiated it is apt to be confounded with the Armadillo "sclater" or woodlouse. As long ago as Stewart's time it was known in the neighbourhood of Edinburgh, where it still occurs sparingly, under stones on dry banks, in a few localities. Judging by my own experience, I should say it is commoner in the west of Scotland than in the east. Johnston (5) considered it common, however, in Berwickshire in his day. Recorded as fairly common in south of England, Wales, and Ireland. Known also from Norway, Denmark, and other parts of the Continent.

Local data.—Arthur's Seat, Edinburgh, a few, March 1889; Blackford Hill, sparingly under stones, May 1900, and other occasions, ! P.; Ravelrig near Balerno, one, Oct. 1896; near Bo'ness, May 1901 (from R. Godfrey); foot of Glencorse Reservoir, Pentlands, one, Sept. 1901.

Family **POLYDESMIDÆ.**

Polydesmus complanatus (Linn.).

Generally distributed and common in the wooded and cultivated parts of the area, but, like most other Diplopods, it

shuns the higher treeless tracts. A favourite habitat is under bark and moss on a rotten tree or among dead leaves, but I find it also under stones and planks in old quarries and by the sides of fields, etc. A common European species, ranging west to Norway and Ireland.

Local data.—Harburn, under log, ad., Oct. 1895; Mortonhall, under bark and moss, and quarry near Swanston, common under stones, March 1901 and other years, !P.; Duddingston, ad., Roslin, Penicuik, and Balerno (where young only 3 to 4 mm. in length were found), April; Kirknewton Woods, March, !E.; Edinburgh Botanic Garden, Feb. and Oct.; Ormiston Hall, March, and near Gifford, April; Dalmeny Park, March and May; Craigie Hill, ad. ♂, April; Abercorn Glen, May; near Bo'ness, adults, young, and eggs, June; Cullalo, Fife, ad. and several imm., Feb.; St David's, young, length 7 mm., segments 18, nearly white, Sept.; Aberdour, Oct.; Culross and Tulliallan, April; Bridge of Allan, April; Callander, Sept.; etc.

Polydesmus denticulatus, C. L. Koch, ?

Females of a smallish *Polydesmus* found on a few occasions probably belong to this species; but as Mr Brölemann, who has seen a specimen, remarks, one cannot make sure of the species without examining an adult male. They accord well with Norwegian specimens kindly sent me by Mr Ellingsen.

Local data.—Abbey Craig, near Stirling, two, Oct. 1901; Leadburn, one, March 1905; Kirknewton, one, March 1906.

Brachydesmus superus, Latz.

Apparently rare, but it is an insignificant species, and liable to be passed over as a young *Polydesmus*. My specimens agree perfectly with Norwegian ones. Recorded from England (common) and Ireland; and Sinclair (15) states that he has found it in the north of Scotland. In this genus the full number of body-segments is 19, as against 20 in *Polydesmus*. This, it has to be remembered, applies only to adults.

Local data.—Kincardine-on-Forth, two ♀ ♀, April 1901; foot of Cocklerue, Linlithgow, two ♂ ♂ and a ♀, under stone, Jan. 1902.

[**Paradesmus gracilis** (C. L. Koch).

Originally imported, doubtless with exotic plants, this tropical species is now found in hot-houses over most of

Europe, including Britain. In hot-houses in and around Edinburgh it is common, and, to all appearance, quite established, examples of all ages being present.[1]

Local data.—Greenhouses at Morningside, several, Dec. 1898, !P.; hot-houses at Corstorphine, ♂ ♂ and ♀ ♀ ad. and imm., common under flower-pots, May 1905, !B.; Royal Botanic Garden, Edinburgh, adults (both sexes) and young, 1904-1905, !E.]

Family **CHORDEUMIDÆ.**

Atractosoma polydesmoides (Leach).

Atractosoma latzeli, Verhoeff, 1891.

Although fairly well distributed and not rare, this easily recognised species cannot be said to be of frequent occurrence here. Its usual habitat is under planks and stones. First recorded from Scotland by myself (12*b*), and subsequently from "Clyde" by Boyd (13). Common in south of England, and recorded also from Ireland (Pocock, 9). Has apparently not yet been found outside the British Isles, where, according to Pocock, it (he uses the name *A. polydesmoides*) is the only known representative of the genus. I assume, therefore, that Verhoeff's *A. latzeli* from the south of England (8) is the same as Leach's species.

Local data.—Foot of the Pentlands at Hillend, ad. ♂, Dec. 1900; Morningside, several in garden, March 1901 and Oct. 1905, !P.; Blackford Hill, ad. ♂ and ♀, Jan., !E.; quarry near Swanston, ♀, March 1906; Edgelaw, one young, June 1902; Balerno, one, Feb. 1905; South Queensferry, one, March 1901, !P.; near Bo'ness, several imm., May (R. G.), and ad. ♂, four ♀ ♀, under stones and bricks, Aug. 1901; near Linlithgow, a few, Aug. 1901, and ad. ♀, Jan. 1902; near Inveravon, one, Feb. 1903; Aberdour, ♀, Oct. 1903; North Queensferry, ♀, April 1906; Blairadam, one, May 1905; Culross, one, April 1901, !P.; Abbey Craig, near Stirling, ♂, 2 ♀ ♀ ad., Oct. 1901; Tulliallan, ad. ♂, 2 imm. ♀ ♀, Nov. 1904.

Craspedosoma rawlinsii, Leach.

To us this species is of special interest, seeing Leach's types were got in this district. Writing in 1814, Leach

[1] A few other foreign Myriapods, including *Polydesmus coriaceus*, Porat (♂ ♂ ♀ ♀ common, !B.), and the Geophilid *Mecistocephalus carniolensis*, C. L. K., have been found living in hot-houses at the Botanic Garden.

(2, p. 407) said of it: "Discovered by a very assiduous entomologist, Richard Rawlins, Esq."—whose premature death he laments in a footnote—"under stones near Edinburgh, where it appears to be pretty common; it has since been observed under the bark of decaying willow-trees and moss near Roslin and in Ravelston Wood." In another paper (3, p. 380) he says: "Habitat inter muscos et sub lapidibus prope Edinburgum vulgatissima. Detexit R. Rawlins, cujus nomen gerit." In his *Zoological Miscellany* (4) there is a coloured figure of the animal. At the present day I should describe it as widely, but sparsely, distributed; in my experience it is nowhere common. It is entered as "rare" in Johnston's Berwickshire list (5); Gibson-Carmichael (7) knew it only from the neighbourhood of Edinburgh, and the only record in the Clyde list (13) is my own from Cartland Crags, near Lanark. Unknown in the south of England, or from Ireland. Abroad it has been reported from Norway, Sweden, Denmark, Germany, and Austria-Hungary (Latzel), but apparently not from France. But eastern examples described by Latzel under this name may be a distinct race. The "copulatory feet" in my specimens certainly agree much better with Verhoeff's figures of his var. *simile* than with Latzel's.

Local data.—The Bush, near Roslin, two under log, Oct. 1893, ! P., and Polton end of Roslin Glen, ♀ under bark on rotten stump, March 1905; Uphall, ad. ♂, Sept. 1896; Linlithgowshire side of Avon, near Inveravon, ad. ♂ and ♀, in flood refuse, Feb. 1903; reservoir near Aberdour, Fife, 3 ♂ ♂, in flood refuse, Feb. 1903; Tulliallan Woods, ♂, 2 ♀ ♀, under rotten branch among dead leaves, Nov. 1904; Aberfoyle, ♀, April 1896; Braendam Quarry, near Callander, one under stone, April 1900, ! P.

Family **IULIDÆ.**

Blaniulus fuscus, Am Stein.

This small and, as a rule, darkish brown Iulid is common under bark on dead trees, especially conifers, throughout the area. A previous record of my own (12*b*) seems so far to stand alone for Scotland. South of England (common), and Ireland (Pocock, 9), Norway, Switzerland, etc. Without males, and they seem to be rare, there is always the possi-

bility, Mr Ellingsen tells me, of mistaking this species for *B. venustus*, Mein. (=*B. pulchellus*, Koch); but specimens of the latter which I have received from Mr Hirst, from the south of England, bear a very much greater superficial resemblance to the next species.

Local data.—Mortonhall and woods about Roslin, common under bark on dead firs, March 1900 and other years, ! P.; Woods near Balerno, common, April 1901, etc.; Boghall Wood, Pentlands, many ♀ ♀, under bark on dead ash and elm, March 1902 and March 1906; Leadburn, ♀, under peat, and Kirknewton, several under bark on dead fir, March 1905; Abercorn Glen, a few, May 1901; Carribber Glen, March 1902; and Dalmeny, April 1905; Gifford, several under bark on fir stumps, Oct. 1901, and common, April 1906; Otterston, four ♀ ♀ off old hedge, March 1905, ! E.; Tulliallan, a few, April, and Abbey Craig, Oct. 1901; Callander, Sept.

Blaniulus guttulatus (Bosc.).

Iulus pulchellus, Leach (*nec* Koch).

Abundant and generally distributed, though best known in cultivated districts, where, under the name of "wire-worm," it is a well-known pest, attacking the roots of vegetables and other plants. It is also partial to straw-berries. Of wide range in the British Isles and on the Continent. A very slender, almost white species, with a row of yellow spots along each side. Was recorded long ago from near Edinburgh by Leach (3).

Local data.—Gardens, Morningside, Dec. (1898), July, etc.; Swanston, Roslin, etc., under stones on edges of fields, March 1900, ! P.; King's Park, Edinburgh, April, ! E.; Mortonhall, Oct.; Bilston Glen, among dead leaves, April 1902; Nurseries, Corstorphine, common, May 1905; Ormiston, E. L., June 1900, ! P.; near Gifford, common in earth at roadside, April 1905; Dunbar, common in garden, March; Binny Craig, near Uphall, Sept. 1896; Abercorn Glen, May, and near Linlithgow, Aug. 1901; Craigie Hill Wood, common under stones, April, and Dalmeny, abundant in roots of cabbage, July 1906; Culross, April 1901; Dysart, and near Bridge of Allan, April 1906; etc.

Iulus pusillus, Leach.

Widespread and not uncommon, at any rate in the lowland portions of the area. A small species, with pale dorsal bands and no caudal spike. Was recorded from near

Edinburgh and London by Leach (2, etc.). Appears in Carmichael's Scottish list (7) and Boyd's Clyde list (13), but not in the Irish lists. Wide-ranging in Europe, but not in Ellingsen's Norwegian list.

Local data.—Torduff, near Colinton, March, and Pathhead, south of Dalkeith, Aug. 1900, ! P.; Swanston Quarry, a few, April, and Glencorse, Pentlands, Aug. 1901; Blackford Hill, a dozen under stones, March 1905; Ravelrig, one, April 1905; Archerfield, ad. ♀ in moss, Jan. 1905; Gifford, April 1906; Dunbar, March, and Aberlady, April; South Queensferry, one, under stone, March 1901, and Bo'ness, three, May; Culross and Kincardine-on-Forth, common under stones, April 1901, ! P., ! E.; Abbey Craig, near Stirling, a few, Oct. 1901.

Iulus britannicus, Verhoeff.

? Iulus luscus, Mein. (*nec* Latz.).

This is another small species (length, 15-18 mm.), of a yellowish slaty-grey colour, belonging to the section without caudal process. It is common in this district; but is in a great measure confined to the vicinity of the coast, where I find it under stones in sandy places, and occasionally in the nests of ants (*Lasius flavus,* etc.). Verhoeff, relying on Latzel's description of *I. luscus,* Meinert, described it (8) as different, his types being from south of England. It is by no means certain, however, that Latzel had the true *I. luscus* before him. I have submitted Forth specimens (♀ Culross, ♂ W. Wemyss) to Mr Ellingsen of Kragerö, and he tells me he can see no difference between them and what passes for *I. luscus,* Mein., in Norway. It would thus appear that the species is not confined to Britain, but occurs also in Denmark and Scandinavia. It is what Pocock recorded (9) as *I. luscus,* from Ireland (see also 11). In 1901 (12*b*) I gave an instance of its occurrence in this district, which is the only previous Scottish record.[1]

Local data.—Aberlady, a number under pieces of wood on beach, Sept. 1896 and Sept. 1903; Port-Seton, one under leaves in wood, Oct. 1900, !P.; Aberdour, common under stones at high-water mark, April 1901, ! P.; Culross and Kincardine-on-Forth, common, April 1901, ! P.; North Queens-

[1] I have since recorded specimens brought from St Kilda by Mr James Waterston (*Ann. Scot. Nat. Hist.*, 1906, p. 87).

ferry, several in nests of *Lasius flavus*, and coast near West Wemyss, six ♂ ♂ and many ♀ ♀, under stones on sandy ground, April 1906; Elie, a few, Aug. 1904. My only inland records are—Hillend, Pentlands, ♂ and two ♀ ♀ under stone, Dec. 1900; Quarry near Swanston, large ♀ (22 mm.), March 1905; Roslin, ♀ under a piece of wood lying on wet moss, April 1906. I also find the same species in hot-houses at the Botanic Garden (♂ *britannicus*, ! B.) and elsewhere in Edinburgh. These inland specimens are rather more mottled, and have yellower foreheads than the coast ones.

Iulus punctatus, Leach.

Iulus silvarum, Mein.

Abundant under bark and moss on rotten logs and tree stumps in wooded districts throughout the area, and occasionally under stones, both in woods and away from them. Of medium size; colour, pale brownish-grey, with a row of distinct brown spots along each side, and clavate caudal process. In all the British lists; common also in Scandinavia, Denmark, Germany, etc.

Local data.—Harburn, under log, ad. ♀, Oct. 1895; Blackford Hill, under stone, April 1906; Duddingston Park, under bark, ♂ ♂ and ♀ ♀, April 1901; Mortonhall and Roslin, March, ! P., and Hillend Wood, under bark and stones, common, Dec. 1900; Ravelrig, under stones lying among leaves, common, April 1901; Bilston Glen, among moss and in rotten tree-stumps, April 1902; Arniston, May 1900; Kirknewton, common under stones at roadside, and in logs in wood, March 1906; near Gifford, several, Oct. 1901, and common, April 1906, ! E.; Ormiston Hall, March, and Dunglass Dean, April 1902; near Linlithgow, ♀, Jan., and a few, Carribber Glen, March 1902; Dalmeny Park, ♂ ♀ *in coitû*, May 1906; Bo'ness, several ad., June 1901; Wood near Aberdour, April 1905; on rotten tree-trunks, Blairadam, May 1905; West Wemyss, two, April 1906; Culross, East Grange, and Tulliallan, common, April 1901; Abbey Craig, a few, April 1906; Callander, several, April 1900, ! P.; Pass of Leny, one under stone beside anthill, Sept. Specimens sent to Ellingsen are named by him *I. silvarum*, Mein.

Iulus fallax, Mein.

? *Iulus pilosus*, Newport.

Specimens of an *Iulus* which is widely distributed and fairly common here, have been identified for me by Mr Pocock as the *I. pilosus* of Newport; while Mr Brölemann refers it (as I anticipated) to the *I. fallax* of Meinert. So far as I remember, females only were shown to Pocock, while

both sexes have been submitted to Brölemann, whose determination would therefore seem to be the more certain. As matters at present stand, I feel bound to adopt the name *I. fallax* for this Millipede. Very likely *I. pilosus*—which is the older name—and *I. fallax* are synonymous, but a fresh description of the former, from Newport's types, if they exist, with special reference to the male characters, seems necessary to settle the point. This (or the next) is probably the *I. terrestris* of Leach (*nec* Linn.); and, according to Verhoeff, *I. longabo*, Latz., is also to be referred to it. The confusion thus indicated renders any useful statement on distribution next to impossible. Records of *I. terrestris* in the Scottish lists are valueless. *I. pilosus* has been recorded from England and Ireland (9), and once from Scotland by myself (12*b*). *I. fallax* is recorded from south of England and Wales by Sinclair (15). Abroad it has been recorded from Denmark, Germany, etc., but not from Norway.

Local data.—Ravine east of Duddingston, two ♂ ♂ and four ♀ ♀, April 1901 (specimens from this lot have been submitted to Pocock and Brölemann); Ravelrig, ♀, April 1901, submitted to Pocock; Leadburn, ad. ♂, March 1905; Roslin Glen, ♀, April, and Linburn, near Midcalder, two ♂ ♂, one ♀, May 1906; Pathhead, Aug. 1900, ! P.; Archerfield, imm. ♀, Jan. 1905; Dunbar, March, Aberlady and Boltonmoor, near Gifford, ♀ ♀, April 1906; Craigie Hill, Linlithgowshire, ♀, April 1906; Pettycur, May 1900, ! P.; Culross, two ♂ ♂ and numerous ♀ ♀, April 1901 (specimen submitted to Pocock); coast near West Wemyss, a few ♂ ♂ and many ♀ ♀ under stones, April 1906; Callander, ♀, April 1900, ! P.

Iulus ligulifer, Latz.-Verh.

Iulus scandinavius, Latz., Die Myriopoden, etc.

Widely distributed and by no means uncommon, this species is very liable to be confused with the last. I am indebted to Mr Brölemann, who uses the name *I. ligulifer*, for the determination of a pair of my specimens. Adult ♂ ♂ are abundantly distinct; so much so that the two species have been placed in separate sub-genera, *Leptoiulus* and *Micropodoiulus* respectively, but ♀ ♀ and immature examples are very much alike; with a little practice, however, they can, I think, be separated—at any rate adult ♀ ♀—with

tolerable certainty. *I. ligulifer* is a blacker animal, rather thicker in build and more sparsely haired. In the adult ♂ the modifications in the anterior limbs are extreme. It seems to me, that by the rules of nomenclature, *scandinavius* is the proper specific name of this Iulid, and that the reason given by Verhoeff (8) for discarding it is inadequate. I understand the British Museum possesses English specimens. It is now recorded for the first time from Scotland. Abroad it is on record from Norway, France, Germany, etc.

Local data.—Hillend, near Edinburgh, ♂ and two ♀♀ under stone, Dec. 1900; Swanston Quarry, a number of ♀♀, March 1901 and other years; Woodhouselea, ♂, March 1902; Bilston Glen, near Polton, ♂ and several ♀♀ among dead leaves, April 1902, ! B.; Edgelaw, ♀, June 1902; Blackford Hill, a few ♂♂ and a good many ♀♀ under stones, March and April 1905; near Kirknewton, ♀ and ♂, March and May 1906; near Gifford, ♀, Oct. 1901; South Queensferry, a few under stones, March 1901; Bo'ness, two ♂♂ and three ♀♀, April and May 1901 (R. G.); Cullalo, Fife, one, Feb. 1903; Kincardine-on-Forth, ♂ and several ♀♀, April 1901; near Dysart, several ♀♀, April 1906; Abbey Craig, several, Oct. 1901.

Iulus niger, Leach.

Iulus albipes, C. L. Koch.
Iulus transversosulcatus, Am Stein.

Of our larger Millipedes this is the commonest and most widely distributed. As its various names imply, it is black with white or very pale legs, and with transverse striæ on the anterior half of each segment, which is quite smooth in the two preceding species, the only ones with which it is likely to be confounded. Pocock, no doubt for good reasons, adopts Leach's name, and I think he is right; but on the ground that Leach's description is inadequate, Continental authorities employ Koch's name. The species is not described in Latzel's work, but Verhoeff (8) gives a detailed description of it. Leach (2) says of his *Julus niger*, "It is by far the most common species in the neighbourhood of Edinburgh"; and again (3), "Habitat, sub lepidibus. In Caledonia vulgaris." If Leach's types exist in the British Museum collection, they ought to be fully redescribed, so as to put an end to any dubiety about the use of the name. Under the name *I. niger* in previous Scottish lists, more

than one species has doubtless been included. Recorded from south of England, and also from Ireland. Abroad it occurs in Germany and north of France, but curiously enough it is not recorded from Scandinavia.

Local data.—Mortonhall, Lothianburn, Swanston Quarry, common, ! P.; Boghall, March, Pathhead, south of Dalkeith, Aug., and Morningside, Dec. 1900; Arthur's Seat and Blackford Hill, ♂♂ and ♀♀ common under stones, March, ! E., and Ravelrig, April 1901; Bilston Glen, under dead leaves, April 1902, ! B.; Longniddry, April 1905, etc.; Boltonmoor, near Gifford, April 1906; Abercorn Glen and Bo'ness, May, and near Linlithgow, Aug. 1901; near Burntisland, May 1900; Culross, April, and Abbey Craig, Oct. 1901; Aberfoyle, July 1900; etc. Brölemann and Ellingsen name the specimens sent to them *I. albipes*.

Iulus sabulosus, Linn.

Widely distributed and fairly common, this fine species may be at once known from the other larger members of the genus by the two ferruginous stripes down the back. It is included as common in the three Scottish lists, and is recorded from various parts of England, and also from Ireland. Its range on the Continent is very extensive—Norway to Spain, Hungary, etc.

Local data.—Gorebridge, May, ! P., and Pathhead, near Dalkeith, Aug. 1900, ! P.; Swanston Quarry, one, March 1901; Kirknewton, one, Jan. 1902; Blackford Hill, March 1905; Aberlady, June 1903; Linburn near Dalmahoy, several ♂♂ and ♀♀ under stones, May 1906; South Queensferry, June 1900, ! P.; Bo'ness, several, May 1901 (R. G.); Riccarton Hills near Linlithgow, one, Jan. 1902; Pettycur, Fife, May 1900, ! P.; Culross, April 1901; West Wemyss, two, April 1906; Callander, ♀, April 1900.

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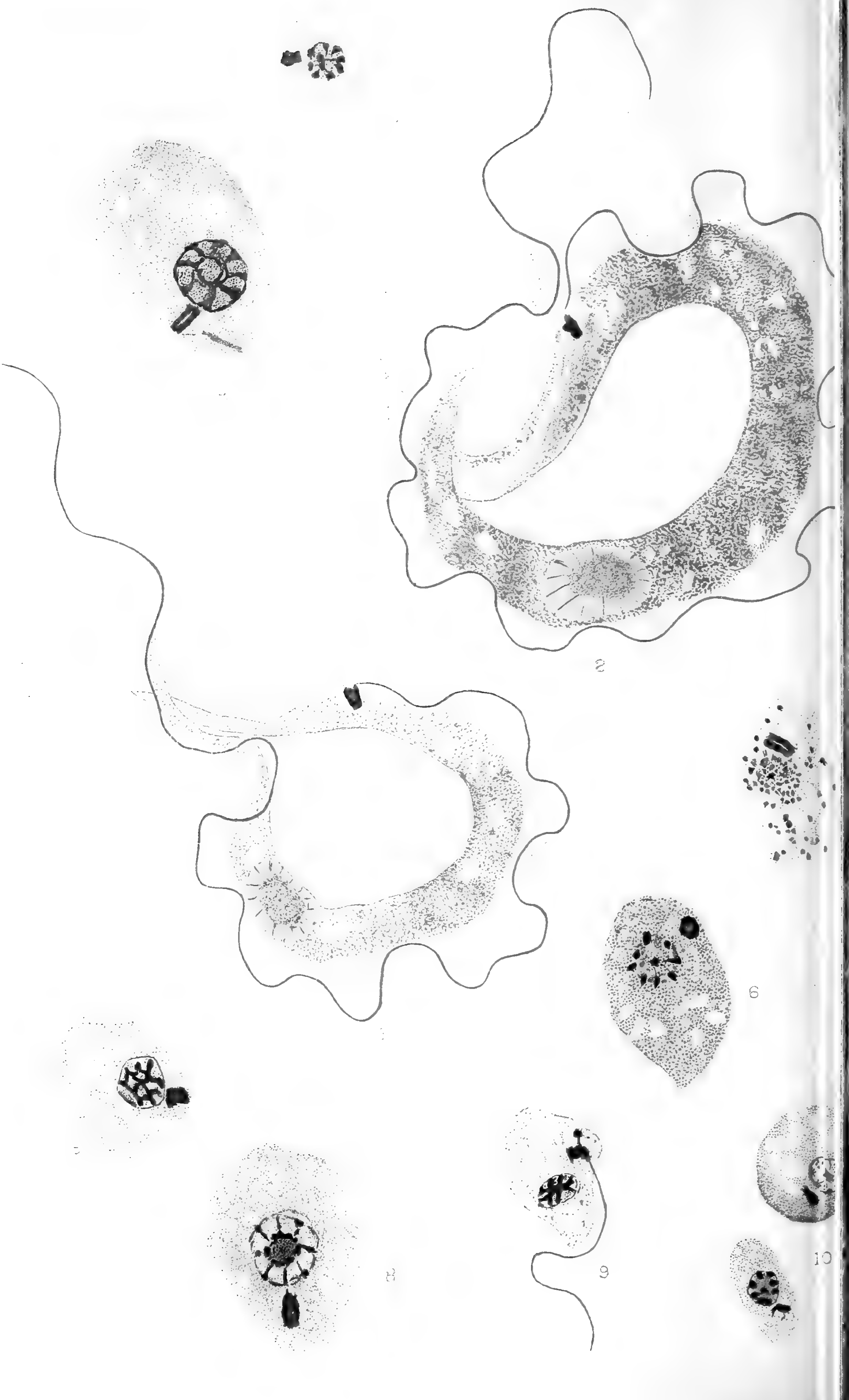
Note.—Just as this goes to press, I have received from Mr W. M. Webb an interesting little pamphlet printed for private circulation, on British Centipedes and Millipedes.

PLATE III.

Photo. J. Ritchie, Sen.

COLONIES OF *SERTULARIA ELONGATA* FROM THE NORTH SEA.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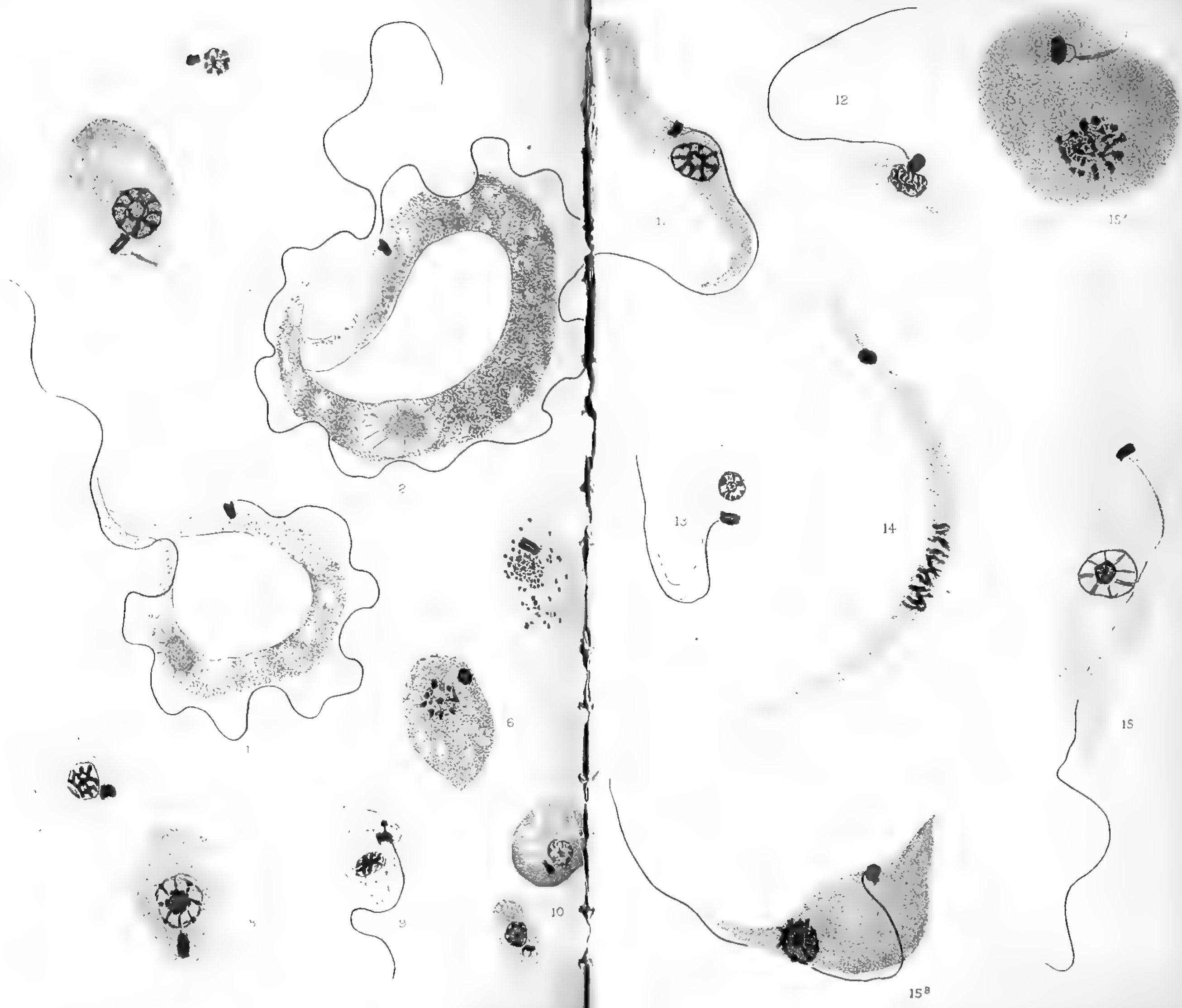
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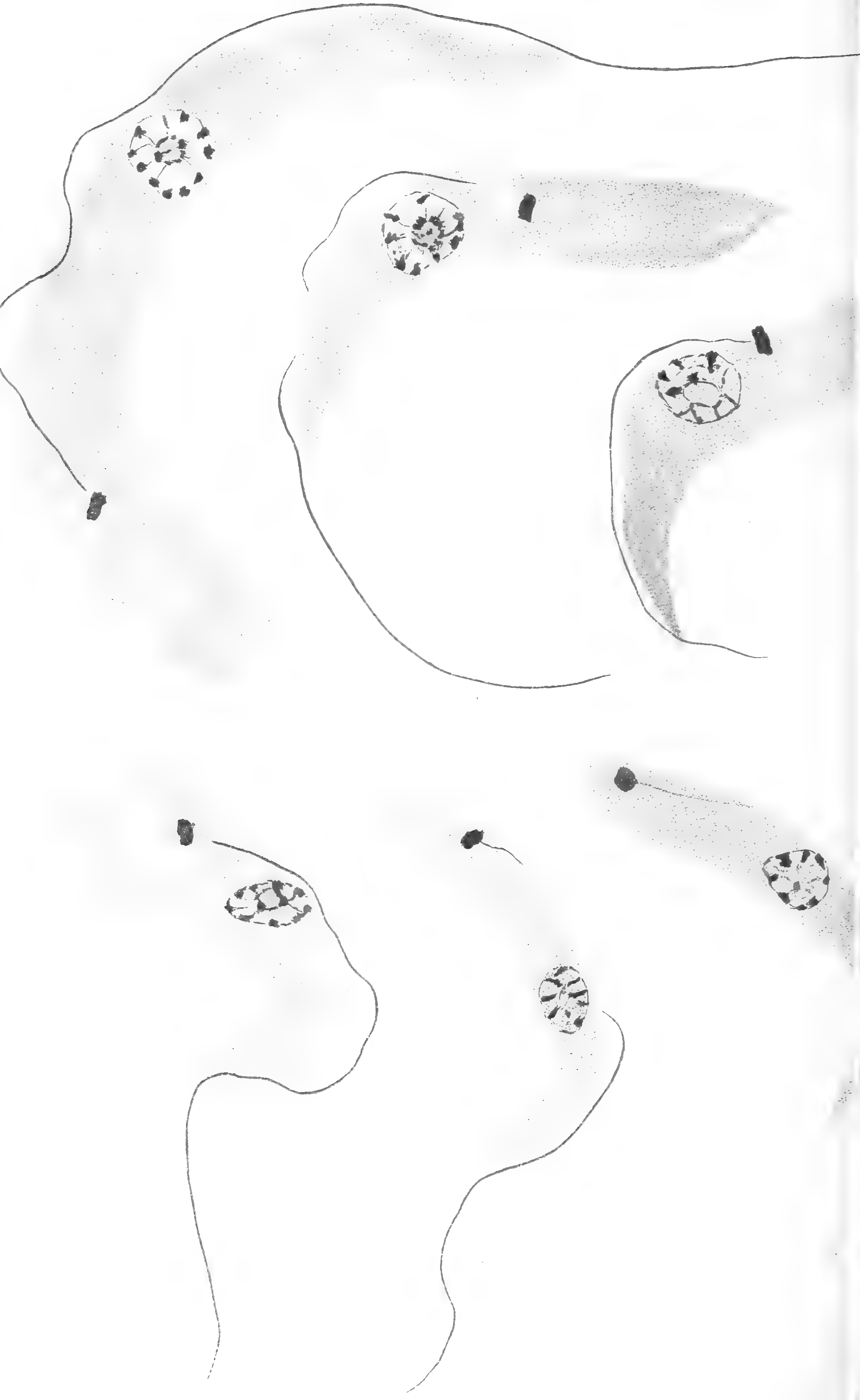

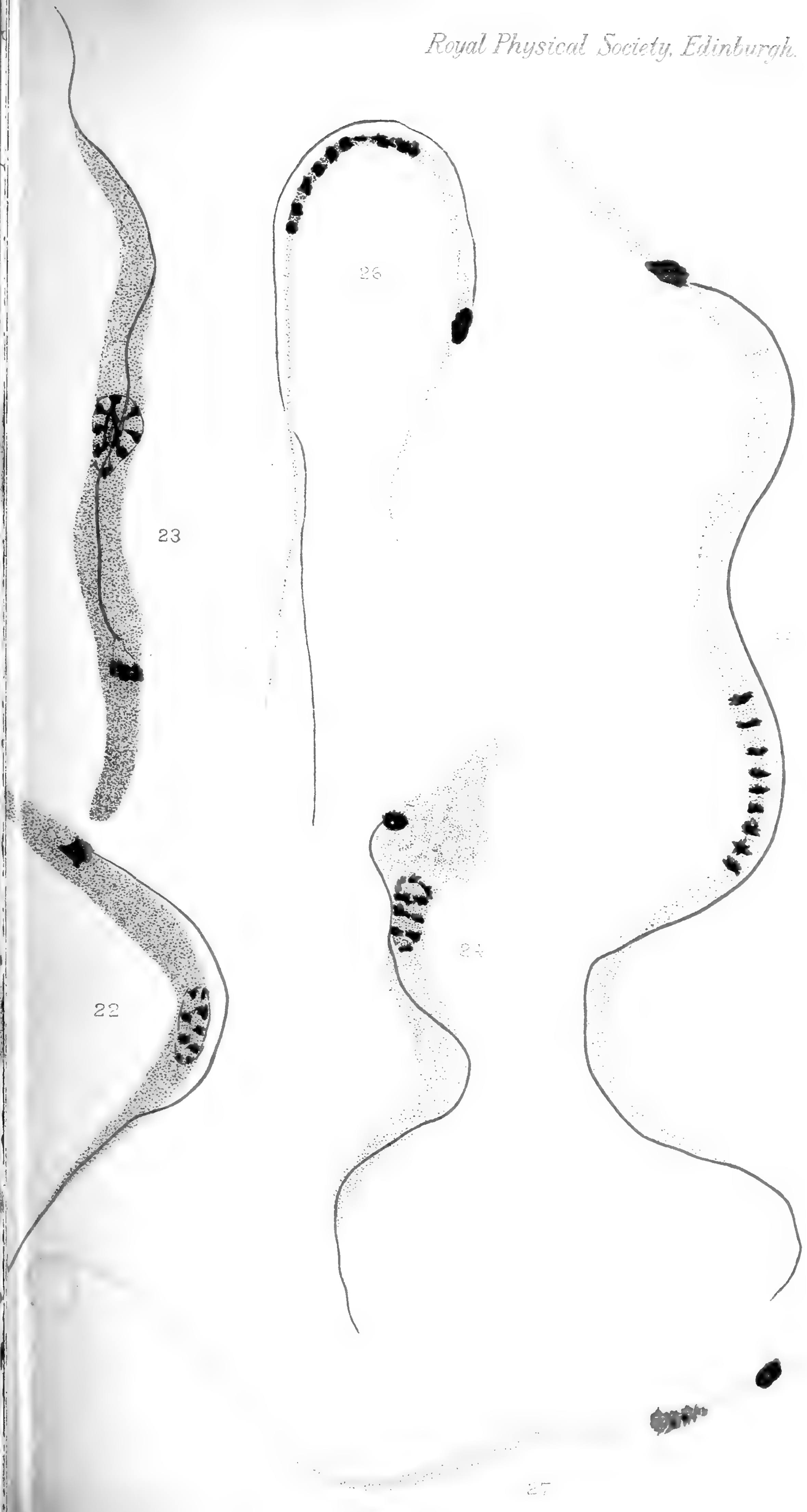
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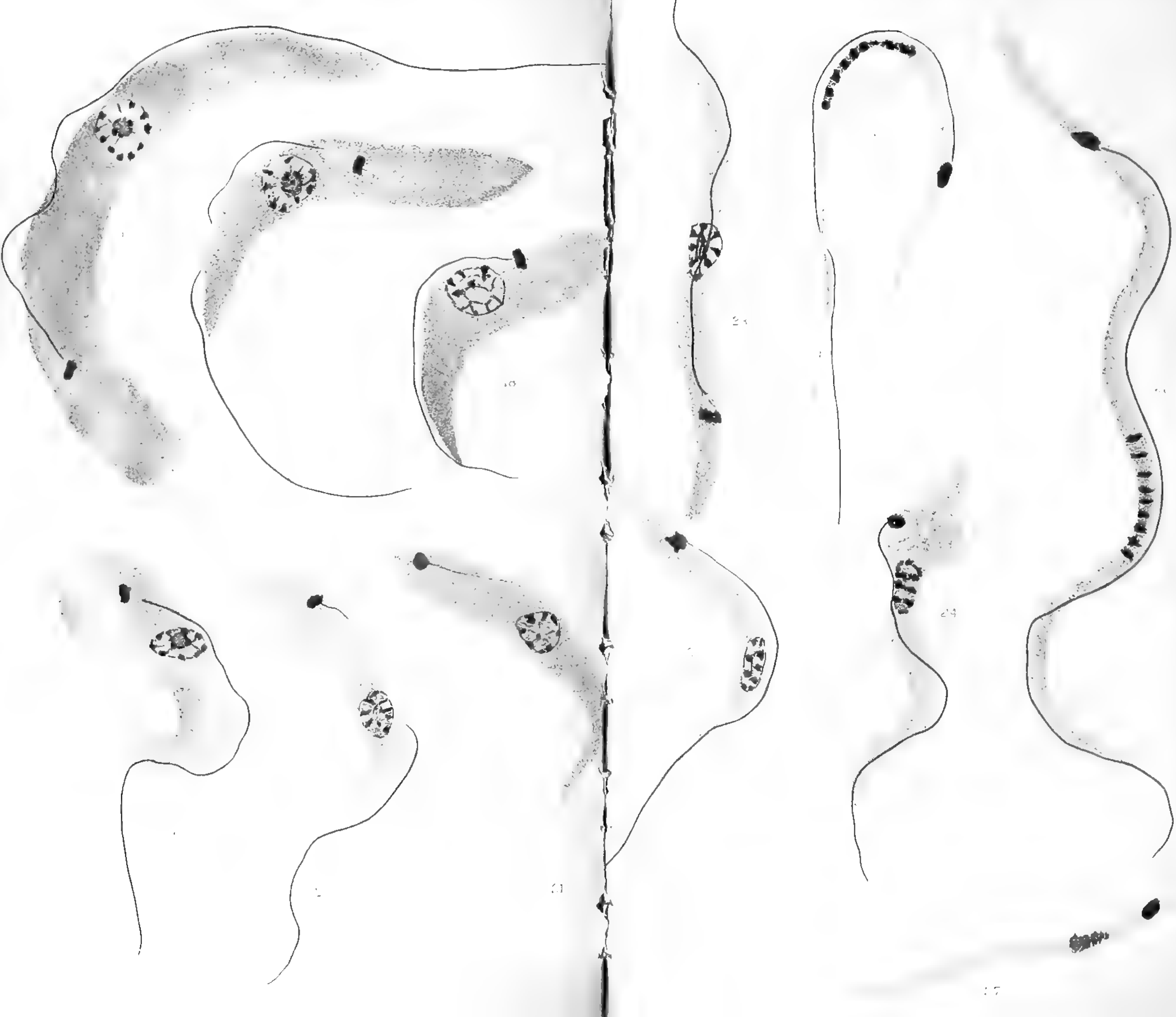

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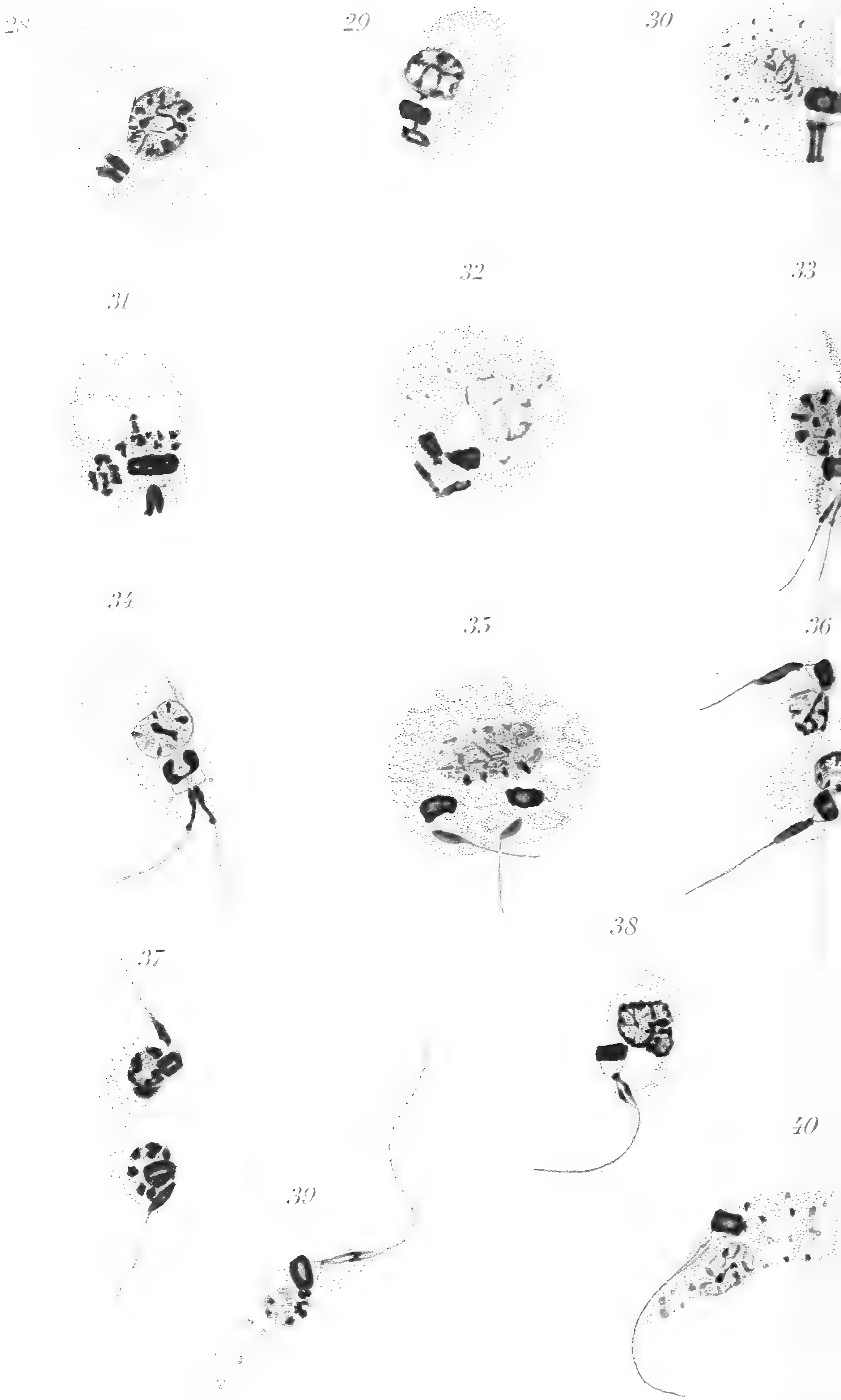

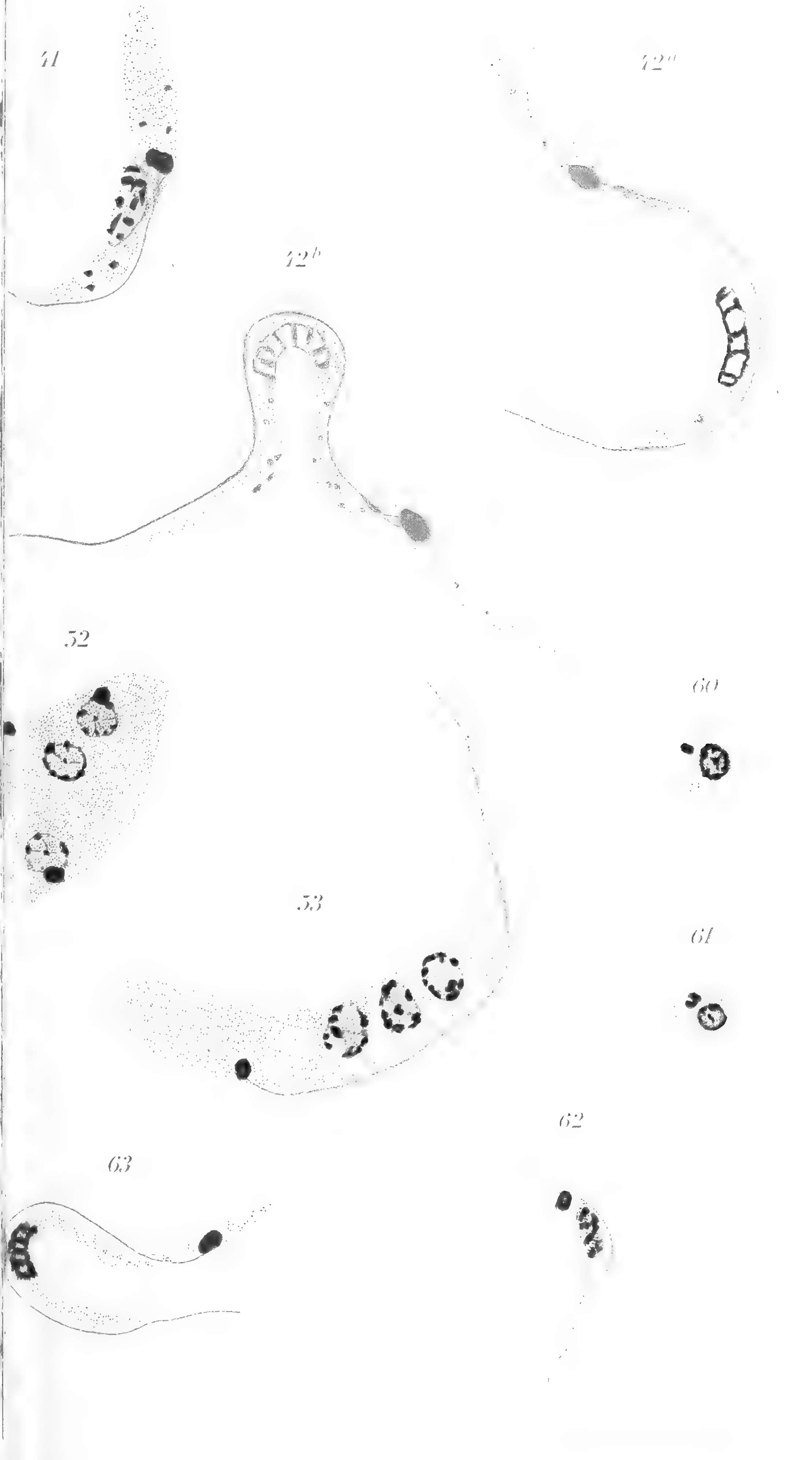
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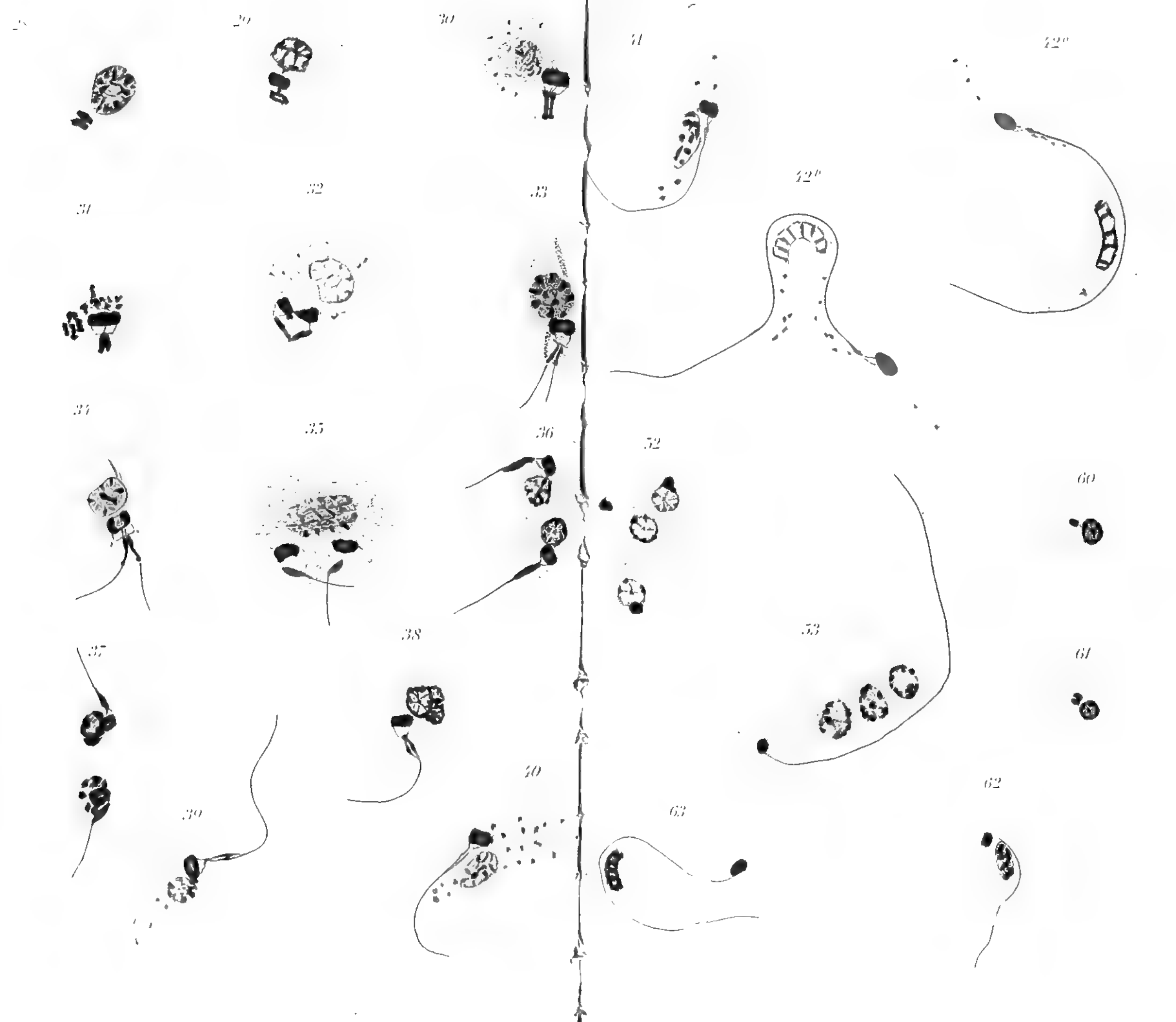
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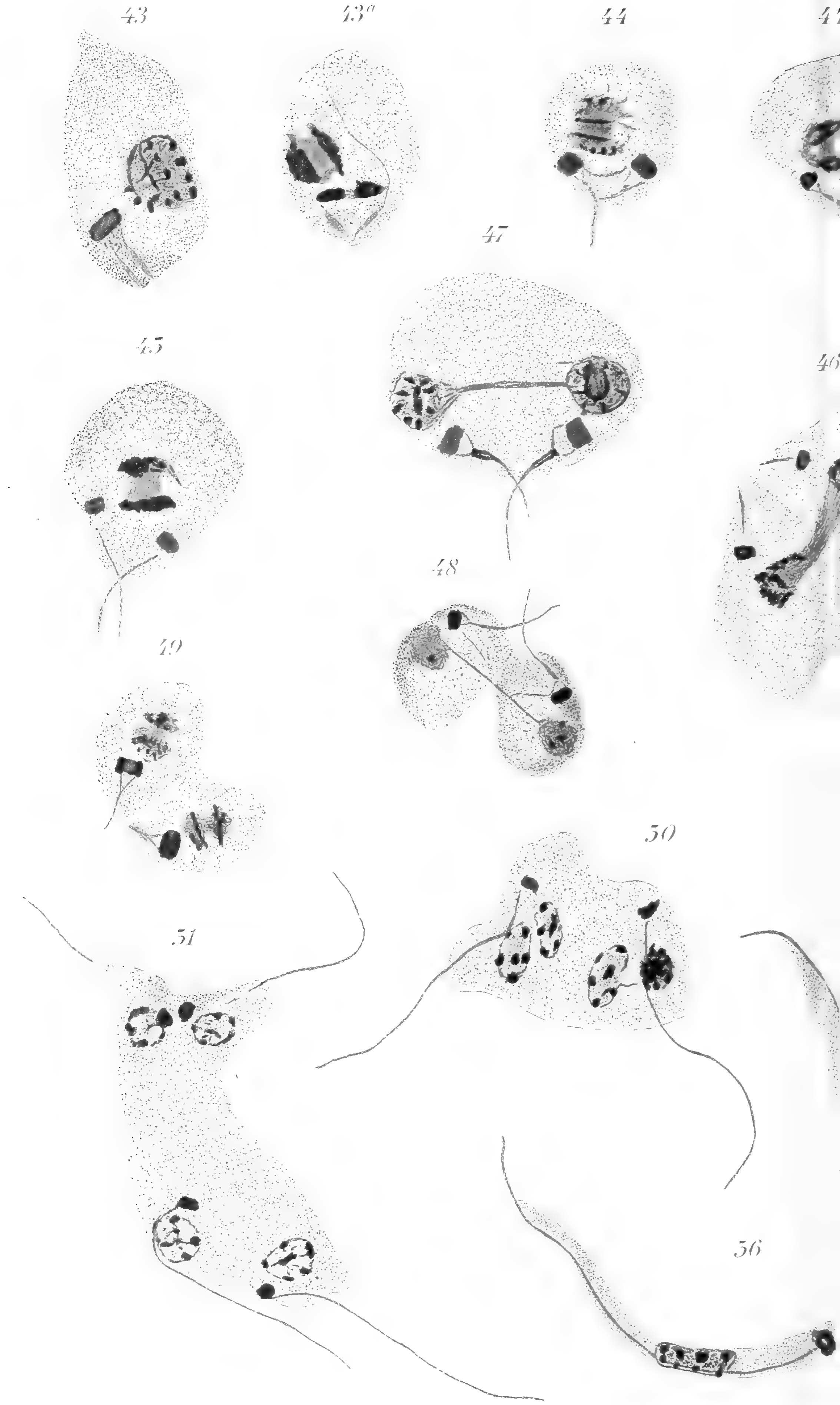
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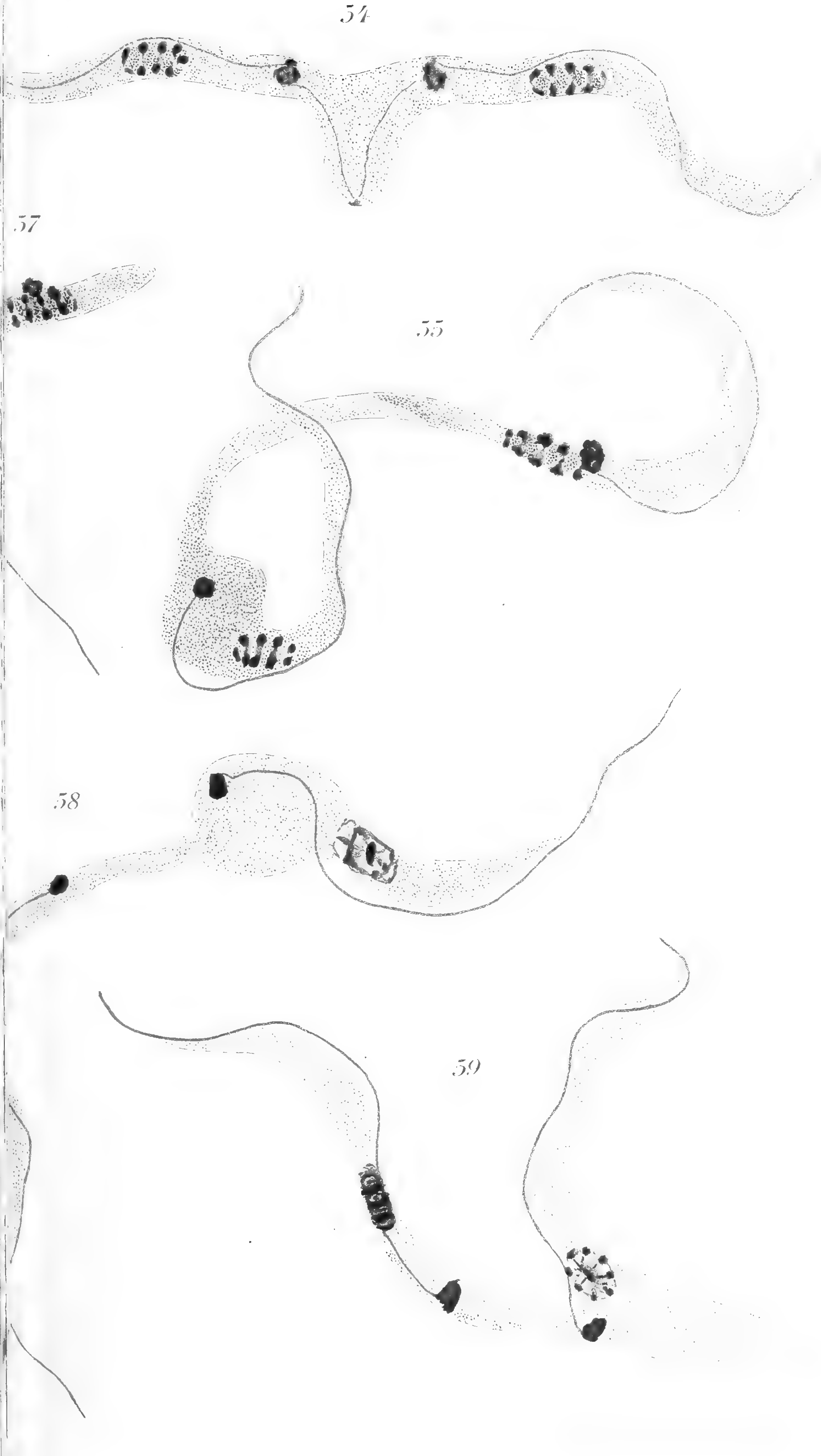
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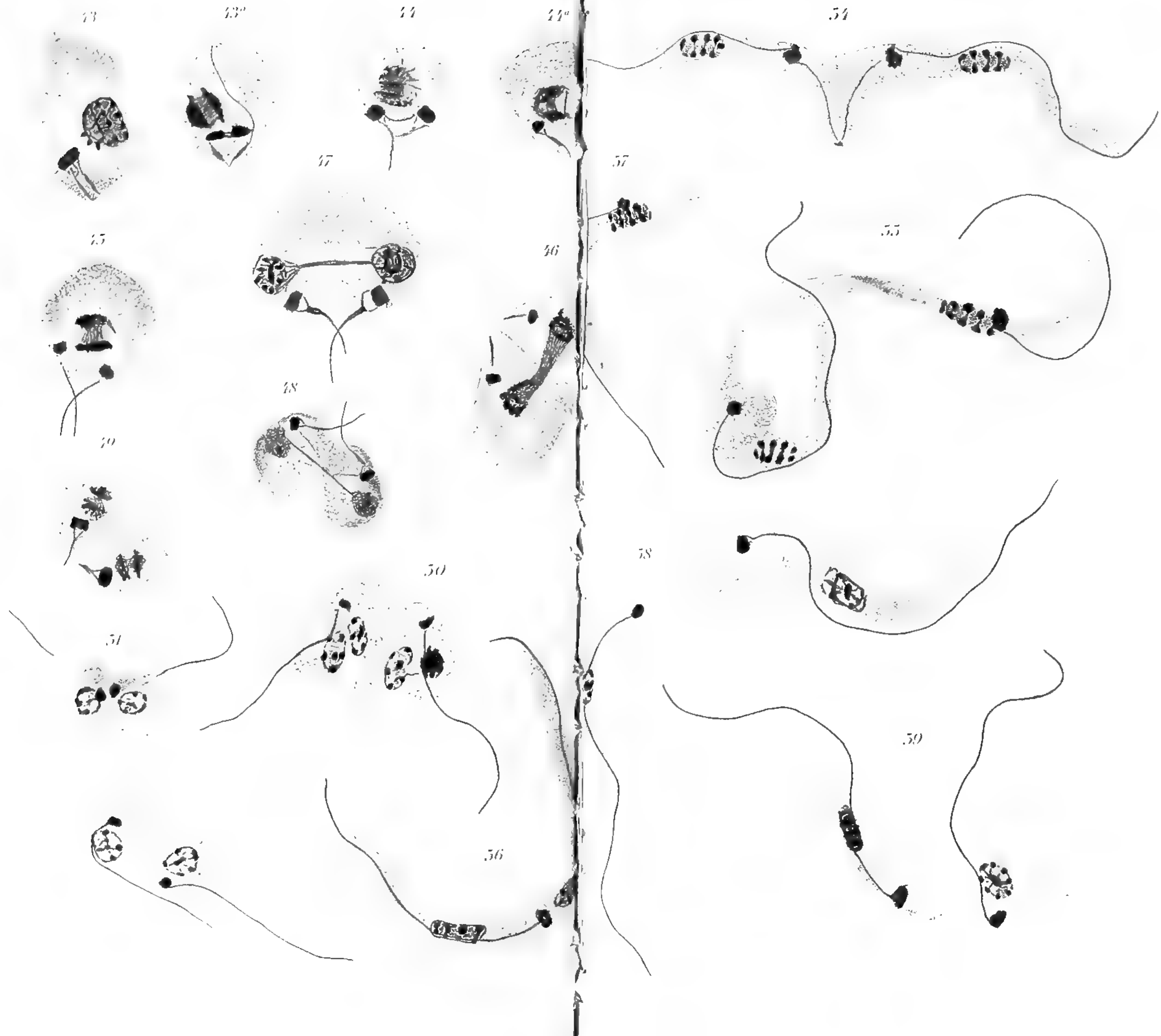

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Do.	Part 2 (1884-85),	7/6	10/	
Vol. IX.	Part 1 (1885-86),	10/	12/6	
Do.	Part 2 (1886-87),	3/6	5/	
Do.	Part 3 (1887-88),	4/6	6/	
Vol. X.	Part 1 (1888-89),	5/	7/	
Do.	Part 2 (1889-90),	10/	12/6	
Vol. XI.	Part 1 (1890-91),	5/	6/6	
Do.	Part 2 (1891-92),	5/	6/6	
Vol. XII.	Part 1 (1892-93),	5/	6/6	
Do.	Part 2 (1893-94),	12/6	15/	
Vol. XIII.	Part 1 (1894-95),	4/6	6/	
Do.	Part 2 (1895-96),	5/	6/6	
Do.	Part 3 (1896-97),	6/	7/6	
Vol. XIV.	Part 1 (1897-98),	5/	6/6	
Do.	Part 2 (1898-99),	5/	6/6	
Do.	Part 3 (1899-1900),	3/6	5/	
Do.	Part 4 (1900-1901),	3/6	5/	

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VIII. *Arctic Rotifers collected by Dr William S. Bruce.* By James Murray, Esq. Communicated by William Evans, Esq., F.R.S.E.

(Read 25th November 1907.)

Dr William S. Bruce has kindly placed at my disposal a considerable quantity of moss collected by him at various times in different parts of the Arctic region.

The expeditions in which Dr Bruce took part when these collections were made are—The Jackson-Harmsworth Polar Expedition, 1896 and 1897; Major Andrew Coats's Expedition to Novaya Zemlya, Wiche Islands, and Barents' Sea, 1898; H.S.H. The Prince of Monaco's Expedition, Spitsbergen and North Polar Regions, 1898; H.S.H. The Prince of Monaco's Expedition, Spitsbergen and North Polar Regions, 1899; Scottish Spitsbergen Expedition, 1906.

All the material obtained on the earlier expeditions was preserved in spirit, except a few tufts of moss from Red Bay, Spitsbergen, and some moss scraped from a walrus skull in Franz Josef Land. Even this moss, which was preserved in the dry condition, was too old to give much hope of finding living Rotifers, and, as a matter of fact, none were found.

In 1906, however, I was able to examine fresh moss, gathered a few weeks previously in Prince Charles Foreland, Spitsbergen, by Dr Bruce, and in this I got many living Rotifers.

The list of Rotifers obtained in all these collections is not a long one. It was intended to delay the publication of the list till an examination could be made of the moss collected by Dr Bruce in this present year (1907), but as circumstances[1] render it impossible that this can be done in the meantime, the list is published as it stands.

[1] Mr James Murray is now absent serving with the British Antarctic Expedition.—W. S. B.

Little work has been done on the Rotifers of the Arctic region. I have seen only two papers—Bergendal's (1) on the Rotifera of Greenland, and Bryce's (3) on the Rotifera of Spitzbergen. Bergendal's work is the most extensive on Arctic Rotifers, and has the advantage of containing observations on the living animals in their native habitat. He gives a list of 76 species (Bryce says 82), 3 of which he did not name. No less than 26 new species are described, but some of them are insufficiently described, and of doubtful value.

As Dr Bruce's collections were all made in the islands lying in the north of the eastern hemisphere, only records from this region will be included in the appended Table showing the distribution of the species, so far as known.

Mr Bryce's paper (3) is the only important one which I have seen dealing with this region. It contains a list of species found in a collection of moss made by Prof. J. W. Gregory on Sir W. Martin Conway's Expedition to Spitsbergen in 1896. Twenty-six species are enumerated.

Mr Bryce mentions that Goes (6) found 2 species of *Callidina*, which he did not name, in Spitsbergen, and that Ehrenberg (5) found *Callidina alpium* (4) in material collected in Spitsbergen in 1867. This would seem to be the only definite record, previous to Bryce's, of a Rotifer from these islands. He further refers to several lists which have been published for Greenland, but does not more specifically refer to any of them but Bergendal's.

Spitsbergen.

The available material consisted of about a dozen packets of dried moss, lichens, *Selaginella*, etc., from Red Bay, 1899; some jars of moss and other plants from Recherche Bay, 1899, preserved in spirit; a large quantity of fresh moss from Prince Charles Foreland, 1906.

As might be expected from the examination of fresh moss, a much larger number of species was got in Spitsbergen

than in any of the other districts examined, but it falls short of that obtained by Mr Bryce. The two lists will be compared afterwards.[1]

As is usual when Rotifers are collected from moss, the Bdelloida preponderated over the other orders.

Œcistes serpentinus, Gosse. Prince Charles Foreland, one small example, living, no doubt hatched from an egg.

Philodina brevipes, Murray. One large example, living, Prince Charles Foreland.

P. alpium (Ehr.) (4). Prince Charles Foreland.

P. brycei (Weber) (8). Prince Charles Foreland, numerous. The form found is slightly different from the type, as there are two spines on the preanal segment to which Weber does not refer. There are 10 spines in the principal row, and in front of the spine, at each end of the row, there is another spine on the same lateral skinfold.

Callidina angusticollis, Murray (7). Prince Charles Foreland. Several cases.

C. papillosa, Thompson. Recherche Bay. This is one of the small number of Bdelloids which can be recognised, even when dead, by characteristic processes on the trunk.

C. plicata, Bryce (2). Recherche Bay and Prince Charles Foreland. In the latter locality the type was common. In Recherche Bay an interesting variety was found, which has the processes on the posterior hood produced into long tails. The same form is common in Scotland, and especially on mountain tops.

C. bidens, Gosse. A fine active species was abundant in Prince Charles Foreland. It appeared to me to be a distinct species from any known to me. Gosse's species, *C. bidens*, is insufficiently described, and is unrecognisable. I learn that Mr Bryce intends to establish Gosse's name, by describing more fully an animal which answers Gosse's description as far as that goes. From Mr Bryce's drawings of the proposed type of *C. bidens*, which he kindly sent to me, I believe our Spitsbergen animal is the same, and record it under that name.

[1] The special interest in Dr Bruce's collection lies in the fact that no material had previously been recorded from Prince Charles Foreland.

C. russeola, Zel. Prince Charles Foreland and Red Bay.

C. incrassata, Murray (7). Prince Charles Foreland, abundant. This is the most interesting Bdelloid found. It has hitherto only been known as a native of Scotland, and there it appears to be rare, though widely distributed. I have taken it in three localities—Fort Augustus, Inverness-shire; the island of Rousay, Orkney; and the mainland of Shetland. Mr Wm. Evans has also collected it in several localities in Scotland.

Rotifer vulgaris, Schrank. Prince Charles Foreland, 3 examples, living. These were enclosed in lax tubes of floccose matter, such as are commonly found with *R. macroceras.*

Adineta vaga (Davis). Prince Charles Foreland.

In addition to these Bdelloids, there was one pellet-making species of *Callidina*, very common in Scotland, but not yet named.

Diglena ferox, Western (9). Prince Charles Foreland, one example.

Monostyla bulla, Gosse. Prince Charles Foreland, alive.

M. lunaris, Ehr. Prince Charles Foreland.

M. cornuta, Ehr. Prince Charles Foreland.

Distyla flexilis, Gosse. Prince Charles Foreland.

Notholca longispina, Kell. Prince Charles Foreland.

In the Table at the end of this paper the list of Rotifers enumerated by Mr Bryce are compared with those collected by Dr Bruce in Spitsbergen, by setting them in parallel columns.

Franz Josef Land.

All the moss from Franz Josef Land was preserved in spirit, with the exception of one small tuft found on a walrus skull. In the circumstances there was little likelihood of finding many Bdelloids, as only those species can be recognised when dead which have conspicuous processes of some sort. Only 8 species of Rotifers were found, of which only 2 were Bdelloids, and 3 could not be named.

Floscularia sp. A large animal, with the corona insufficiently displayed for identification. Eight large eggs were enclosed in the tube. Cape Mary Harmsworth.

Callidina papillosa, Thompson. Cape Forbes.

C. plicata, Bryce (2). Cape Mary Harmsworth. On old walrus skull. *Variety* having the caudal processes greatly elongated. Cape Gertrude.

Dinocharis sp., probably *D. tetractis.* As the foot was gone, the identification could not be certain. Carpenter's Rock, Cape Flora.

Colurus sp., not identified. Carpenter's Rock, Cape Flora.

Metopidia lepadella (Ehr.). Carpenter's Rock, Cape Flora.

Notholca longispina, Kell. Old walrus skull, Cape Flora.

Anuræa cochlearis, Gosse. Old walrus skull, Cape Flora.

Novaya Zemlya.

Cape Kostin and Medusharsky Island.

Bdelloid. A very large species was abundant in the only collection from this island. It had some resemblance to *Rotifer trisecatus,* Weber (8), but could not be certainly identified.

Rattulus sp., not identified. The style was as long as the body.

Metopidia solidus, Gosse.

Notholca striata, Ehr.

Bear Island.

Bdelloid Rotifers were numerous, but none could be identified.

	Spitsbergen.			Franz Josef Land.	Novaya Zemlya.
	Bruce.	Bryce.	Ehr.		
Œcistes serpentinus, Gosse, . .	×				
Philodina alpium (Ehr.), . .	×	×	×		
,, *erythrophthalma*, Ehr., .		×			
,, *rugosa*, Bryce, . .		×			
,, *brycei* (Weber), . .	×				
,, *brevipes*, Murray, . .	×				
Callidina lata, Bryce, . . .		×			
,, *constricta*, Duj., . .		×			
,, *venusta*, Bryce, . .		×			
,, *aspera*, Bryce, . .		×			
,, *pusilla*, Bryce, . .		×			
,, *cornigera*, Bryce, . .		×			
,, *angusticollis*, Murray, .	×				
,, *bidens*, Gosse, . .	×				
,, *plicata*, Bryce, . .	×	×		×	
,, *habita*, Bryce, . .		×			
,, *musculosa*, Milne, . .		×			
,, *papillosa*, Thompson, .	×	×		×	
,, *tetraodon*, Ehr., . .		×			
,, *russeola*, Zel., . .	×	×			
,, *incrassata*, Murray, .	×				
Rotifer vulgaris, Schrank, . .	×				
,, *tardus*, Ehr., . . .		×			
,, *trisecatus*, Weber (?), . .					×
Adineta vaga (Davis), . . .	×	×			
,, *barbata*, Janson, . .		×			
,, *gracilis*, Janson, . .		×			
Proales decipiens, Ehr., . . .		×			
Furcularia gracilis, Ehr., . .		×			
Diglena permollis, Gosse, . .		×			
,, *ferox*, Western, . .	×				
Stephanops stylatus, Milne, . .		×			
,, *tenellus*, Bryce, . .		×			
Monostyla lunaris, Ehr., . .	×				
,, *cornuta*, Ehr., . .	×				
,, *bulla*, Gosse, . . .	×				
Distyla flexilis, Gosse, . . .	×				
Metopidia lepadella (Ehr.), . .		×		×	
,, *solidus*, Gosse, . .					×
Colurus caudatus, Ehr., . .		×			
Anuræa cochlearis, Gosse, . .				×	
Notholca striata, Ehr., . . .					×
,, *longispina*, Kell., . .	×			×	

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IX. *"Scotia" Collections.—Note on Microscopic Life in Gough Island, South Atlantic Ocean.* By James Murray, Esq. Communicated by William Evans, Esq., F.R.S.E.

(Read 25th November 1907.)

By favour of Dr William S. Bruce and Mr R. N. Rudmose Brown, I was allowed to examine a small tuft of moss from Gough Island, or Diego Alvarez. The material was collected by the Scottish National Antarctic Expedition when the "Scotia" visited the island in April 1904.

Mr Brown (1) speaks of the luxuriant vegetation of the island, which is "clothed in green from the water's edge to almost the summit," of the "moss-clothed cliffs and luxuriantly growing ferns and flowers" (2), suggesting a paradise for the microscopist. It may be confidently affirmed that Gough Island will be found to have a rich microscopic fauna, as every land yet investigated, having a climate favourable to the growth of moss, maintains abundant microscopic life of many classes.

It was therefore with disappointment that I found the one little tuft of moss available to be an unfavourable specimen. It may have been already washed, in preparing it as a botanical specimen, but the sediment I obtained by washing was very small in quantity, and contained few recognisable organisms.

As Dr Bruce assures me that everything found will be new for the island, I am induced to publish a note on the very meagre result obtained.

Rotifera.

Philodina flaviceps, Bryce (3). A species only recently discovered in Scotland, and easily recognisable by the spurs, which are very short.

Callidina angusticollis, Murray (4). One of the most widely distributed of all Rotifers. The case only was found on Gough Island, and measured $\frac{1}{132}$ inch (190 μ) in length.

Bdelloid egg. Similar to that of *Philodina citrina*, which has a prominence at one pole of the egg. Several species, of different genera, have this type of egg, so that no certain identification can be made from it.

Rhizopoda.

Heliopera petricola, Leidy, var. *amethystea*, Penard.

Difflugia sp. Of hemispherical form, like an *Arcella*.

Euglypha ciliata (Ehr.).

Euglypha sp. No spines, section circular. A Rhizopod, with the form of a *Euglypha*, and similar surface plates, but without spines, has been found in Scotland also.

In addition to the four species named, there were two worms, a *Nematode* and an *Oligochœte*, and a blue-green tabular *Alga*, with the cells grouped in multiples of four.

In studying the micro-biology of lands previously unexplored, one does not anticipate much peculiarity, even in the most remote islands. The reason for this is that the majority of microscopic fresh-water or land species are what Jenning's calls "potentially cosmopolitan," that is to say, they can be conveyed through the air to all parts of the world, in the form of eggs or spores, or even in some classes in the adult condition, and may settle down in any part offering favourable conditions.

Some classes are not so easily conveyed as others, and there is always the anticipation that there may be peculiar insular forms in any unexplored island to stimulate the interest of naturalists.

On account of the high seas and the dangerous coast, it was only with great difficulty that we effected a landing, and it was only possible to remain ashore for a few hours. Hence the small collections! Gough Island undoubtedly holds out a splendid and interesting field for the investigation of its invertebrate fauna.—W. S. B.

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X. *Variation in the Norway Lobster* (Nephrops norvegicus). By D. C. M'Intosh, M.A., B.Sc., F.R.S.E. (From the Zoological Department, University of Edinburgh.)

(Read 28th October 1907.)

The purpose of these notes is to record the results of an examination of Norway lobsters, in which the following three points have been specifically dealt with:—

1. The relative size of males and females.
2. The relative proportions of the sexes.
3. The variation in the number and in the arrangement of the male genital apertures.

For various reasons it was sometimes found convenient to make the examination and to record results with only

one of these points in view, but as no attempt is being made to establish any correlation among the different features considered, the conclusions are independent of the fact that different numbers were handled for each investigation.

MATERIAL.

The material consisted partly of the stock of Norway lobsters in the Zoological Department of Edinburgh University, and partly of hauls taken in the Firth of Forth and in the Moray Firth. Those belonging to the University, which, for convenience of reference, are called "Zool. Lab." specimens, were obtained from the fish-market at Newhaven, and were sent in during the autumn and winter of 1906-7. They were, in most cases, examined when fresh, and just before being assorted and preserved for dissection. It may, I think, be assumed that they were dredged in the area of the Forth, from ground usually frequented by Granton trawlers when fishing for *Nephrops.* Though the quality and the numbers in the different boxfuls, which were supplied at irregular intervals, varied greatly, every specimen of the 1359 examples brought in was examined.

It is desirable to give some particulars regarding the others, which are divided into lots, according to place, time, or method of capture. But it is necessary, in the first place, to state that the ordinary trawl-net used had a mesh of about $2\frac{1}{2}$ inches, decreasing towards the "cod-end" to about $1\frac{3}{8}$ inches, and that occasionally a small-mesh net, with a mesh of about half an inch, was put on, as a sort of loose cover, over the "cod-end" of the ordinary trawl. This small-mesh net is useful in that it captures much of what might otherwise escape through the wider meshes of the trawl. Some details of the various hauls are summarised in Table III. The eight lots (Lots A to H) represent the result of fifteen hauls. In ten of these an ordinary trawl, with a head-line of 90-100 feet, was used. When Lots B, C, D, and G were being caught, a small-mesh net was put on in addition, and on each of those occasions the numbers taken in each of the nets

were noted. While not a single *Nephrops* was found in the small-mesh net in the case of Lot D, yet in Lot G there were 585 specimens in the ordinary trawl and 145 in the small-mesh net. Thus the proportions are very variable.

Other particulars are apparent from an examination of Table III. At times it was not possible to examine all the specimens brought on board, and in such cases a rough estimate is given of the proportion examined. In a number of cases the temperature of the water, which varied, according to the season of the year, from 6° C. to 12° C., was noted both at the bottom and at the surface. The nature of the ground on which *Nephrops* is found is also occasionally indicated, and it appears to be, in general, of a muddy character. The depth varied from about 12 to over 70 fathoms, the average depth being about 30 fathoms. The date of capture of each lot is also given, as well as the locality where each haul was taken. Special attention is directed to the seventh haul of Lot A and to the second haul of Lot C, for in those cases, instead of the ordinary trawl, there was used a small trawl with a 30-foot head-line, having only a small mesh, this being very similar to the small-mesh net already referred to.

It is worthy of note that of the large number of specimens examined, only one had recently moulted, while only eleven females were found bearing ova.

1. On the Relative Size of Males and Females.

This is dealt with in Table I., which is self-explanatory. Measurements of length are there recorded for 5165 specimens. Those measurements, which were taken from the tip of the rostrum to the end of the telson while the animal was placed, with its back downwards, on a graduated board, are given to the nearest centimetre. The Table shows readily the number of individuals, arranged according to sex, of any particular length in the various lots examined. The most obvious fact is that the females are considerably less in length than the males. I was prepared for this difference in

TABLE I.—*Table of Lengths of Sexes.* (M. = Male, F. = Female.)

Length in cms.	Zool. Lab. Box 1.		Lot A.		Lot B.		Lot C.		Lot D.		Lot E.		Lot F.		Lot G.		Lot H.		TOTAL.		Relative Percentage of Males or Females compared with Females or Males of same lengths.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
3	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	0	1	0	100
4	–	–		–		–	–	–	–	–	–	–	–	–	–	–	–	–	0	0	0	0
5	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0	2	0	100
6	–	–	–	2	–	–	–	2	–	–	–	–	–	–	3	8	–	–	3	12	20	80
7	1	1	2	5	–	–	1	2	–	–	–	–	–	–	12	13	2	15	18	36	33·3	66·6
8	2	1	16	24	4	1	1	1	–	–	–	–		–	15	19	16	13	54	59	47·8	52·2
9	3	3	18	35	20	3	2	1	–	–	–	1	–	1	29	20	21	18	93	82	53·1	46·9
10	6	5	55	49	35	12	3	6	–	–	–	–	1	–	40	15	48	20	188	107	63·7	36·3
11	13	9	59	68	52	11	3	19	1	–	1	1	1	–	64	17	58	16	252	141	64·1	35·9
12	27	9	93	49	63	8	7	9	2	1	2	2	1	–	49	14	46	8	290	100	74·3	25·7
13	49	11	106	28	110	1	23	6	11	2	2	1	5	3	87	4	54	1	447	57	88·7	11·3
14	107	20	150	18	133	–	40	2	8		11	1	5	–	60	–	111	–	625	42	93·7	6·3
15	120	14	92	4	123	–	55	–	7	–	17	–	6	2	73	–	145	–	638	20	97·0	3·0
16	80	2	67	3	109	–	72	–	13	–	26	–	10	–	64	–	115	–	556	5	99·1	0·9
17	88	1	41	2	81	–	60	–	12	–	36	–	20	2	45	–	109	–	492	5	99·0	1·0
18	41	–	37	–	36	–	58	–	8	–	51	–	44	–	31	–	86	–	392	0	100	0
19	13	–	17	–	5	–	21	–	11	–	32	–	31	–	28	–	83	–	241	0	100	0
20	3	–	6	–	–	–	12	–	9	–	39	–	29	–	12	–	33	–	143	0	100	0
21	1	–	2	–	–	–	1	–	4	–	15	–	17	–	7	–	6	–	53	0	100	0
22	–	–	1	–	–	–	2	–	4	–	–	–	3	–	1	–	–	–	11	0	100	0
Totals. M. F.	554	76	762	289	771	36	361	49	90	4	232	6	173	8	620	110	933	91	4496	669	87·1	12·9

the sexes, for I had previously recorded[1] measurements of length for 656 Norway lobsters from the Clyde, in which it was found that the average length of males was greater than the average length of females, and that while only one female out of the 656 had a greater length than 160 mm., no fewer than 41 males exceeded that length. It is therefore interesting to know that what was found in the limited number of Clyde specimens is even more marked in the East Coast ones.

The comparative length of the different sexes is further emphasised in Table II., which summarises the present as well as the previous results on this point. From this Table

TABLE II.

Percentages of Sexes at Different Lengths.

Maximum Length in Centimetres.	East Coast Norway Lobsters, giving Percentages between different lengths.		Clyde Norway Lobsters, giving Percentages between different lengths.	
	Males.	Females.	Males.	Females.
Up to 8 cms.	1·7	16·4	22·0	34·1
9 to 12 cms.	18·3	64·3	28·8	38·3
13 to 16 cms.	50·4	18·6	36·4	27·3
Upwards of 16 cms.	29·6	0·7	12·8	0·3
Totals,	100	100	100	100

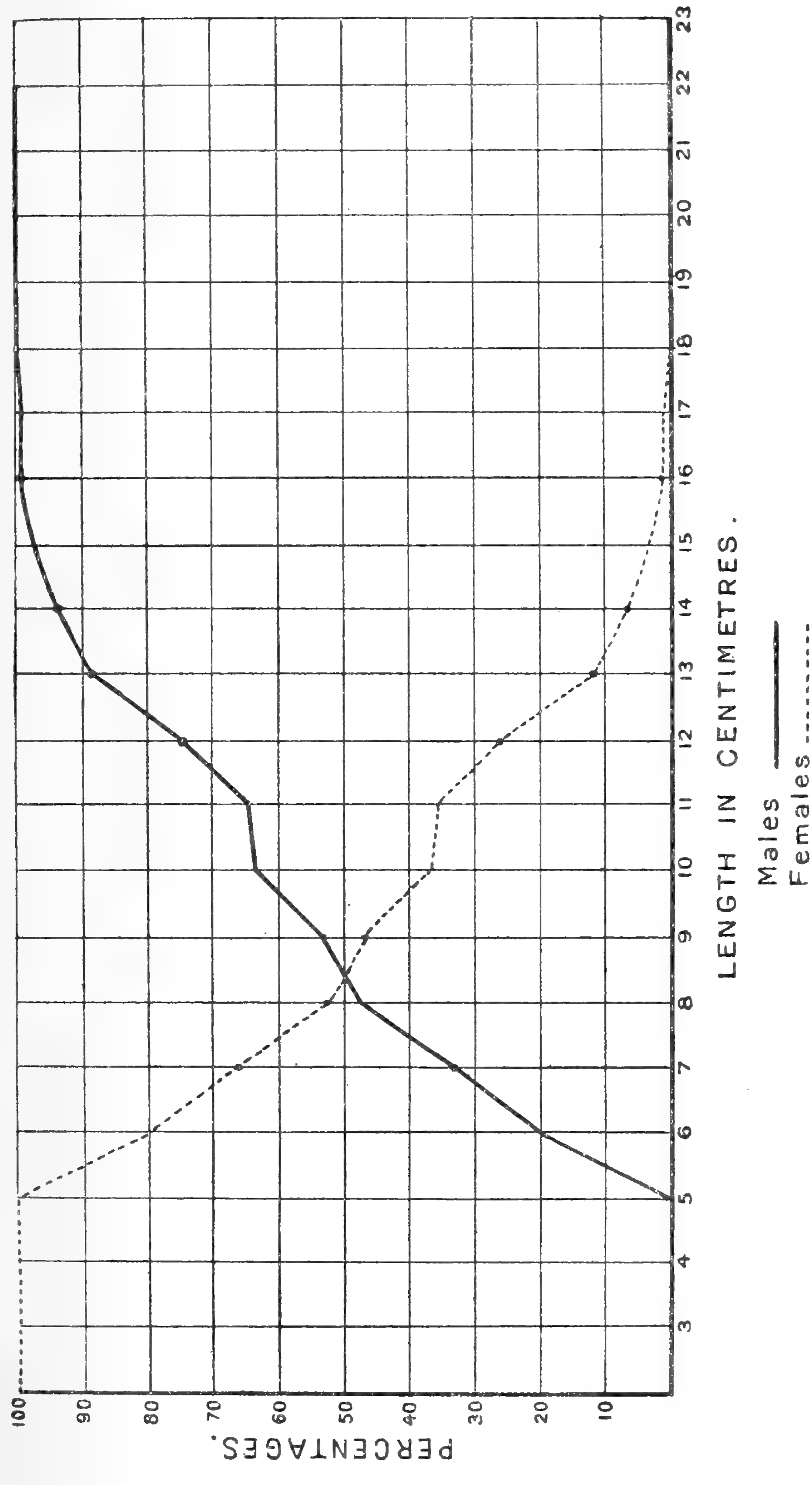
it is seen that less than 1 per cent. of the female, and nearly 30 per cent. of the male, Norway lobsters here examined are over 16 cms. in length. On the other hand, 20 per cent. of the males, as against over 80 per cent. of the females, are under 12·5 cms. in length. From this one seems justified in concluding that the male Norway lobster is in general longer than the female.

[1] *Proceedings of the Cambridge Phil. Soc.*, vol. xii., part v., pp. 441–444 (1904).

Since the various lots which go to make up the total of 5165 specimens here considered were collected at different times, by different methods and in different places, they cannot be regarded as forming a homogeneous group, and therefore in dealing with sizes it is best to compare the *percentage* of each sex at each separate length. (Had the total been a homogeneous group, one would have preferred to form Polygons of Frequency, which would indicate the frequency of occurrence of individuals of different lengths for (1) males, (2) females, and (3) males and females together.) From the percentages, formed in the way indicated and given in the last column of Table I., Diagram I. has been constructed. It is certain that the character of the curves in this diagram would be much altered for animals of from 3 to 7 or 8 cms. in length if a sufficient number of small specimens had been examined. It is obvious, for example, that the curves are much too far apart towards the zero end of the length axis, and that we are dealing with incomplete series. What is wanted is an investigation into the relative numbers of males and females produced, as well as a record of the relative rates of growth. And there are other factors to be considered. We are probably entitled to assume that the sexes begin life with approximately equal numbers, and that the males not only grow larger, but may very well grow more rapidly. It has been found[1] that in the case of *Carcinus mœnas,* "until a carapace-breadth of 15 mm. is reached, male and female crabs exist in equal numbers. After this the females begin to preponderate, until for a carapace-breadth of 36-40 mm. they are more than twice as numerous as the males. When the carapace-breadth exceeds 50 mm. the males outnumber the other sex." Mr Punnett attributes this to a greater rate of mortality among the males, owing to the more frequent risks they run on account of their more active habits. But too little is known of the effect of seasonal changes, sexual activities, and times of moulting, as well as of breeding

[1] R. C. Punnett, *Proc. Camb. Phil. Soc.*, vol. xii., part iv., pp. 293-296 (1904).

DIAGRAM I


LENGTH IN CENTIMETRES.
Males
Females
PERCENTAGES.
100 90 80 70 60 50 40 30 20 10
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

seasons, to enable one at present to write confidently on this aspect of the question. All that is quite clear is that of specimens of *Nephrops* above 8 or 9 cms. in length, the majority of the larger ones are males. The average of all the males examined is 14·8 cms., while the females average only 10·7 cms. If we consider those captured by the large-mesh net only, and they are truly comparable with the "Zool. Lab." specimens taken by the Granton trawlers, we find that their average lengths are higher (15·1 cms. in the males and 11·6 cms. in the females), but the difference in length for the sexes remains about the same.

The Tables given prove that the female adult is in general less in length than the male, while the experience gained in handling the specimens has impressed upon me that the females are not only shorter, but that they are, as a whole, creatures of a more slender build.

2. On the Relative Proportion of Males to Females.

From Table III. it is seen that the sex of 5894 Norway lobsters was determined. Of this total only 703 were females. This proportion, being scarcely 12 per cent., is sufficiently small to be worthy of comment. Since the relative proportions for the various lots are so variable, an examination of the details of this Table does not readily enable one to form any conclusion as to the probable percentage of females in a chance haul, other than the very obvious one that the males in general greatly outnumber the females. It has often been remarked, by those whose duty it is to handle large numbers of Norway lobsters for University classes, that females are comparatively rare. Dr F. H. A. Marshall, for example, has recorded[1] that out of 1068 Norway lobsters sent in to the Zoological Department of Edinburgh University during the summer and autumn of 1901, only 68 were females, and in this connection he suggests that it may be that the majority of females had migrated to a greater distance from land than had the males. The great

[1] *Proceedings of the Zoological Society, London,* January 1902, pp. 2-12.

Different Lots.	Total.	Males.	Females.	Date.	Position.	Temp. of Water at Bottom and at Surface.	Depth in Fathoms.	Trawl used.	Numbers counted.	Nature of Bottom, etc.
Zool. Lab. Box 1	630	554	76	Aut. 1906	[Probably 5-10 miles east of May Island (outside territorial waters). Bought at Newhaven fish-market from Granton trawler.]		[About 29-32]	[In all probability an ordinary trawl net was used]	All	[Muddy]
,, 2	144	143	1	Dec. 1906			,,		,,	
,, 3	299	287	12	Feb. 1907			,,		,,	2 "berried" females
,, 4	286	265	21	Feb. 1907			,,		,,	1 freshly moulted
Zool. Lab. Total	**1359**	**1249**	**110**							
Haul 1	6	5	1	24/2/04			28-32	Ordinary	All	
,, 2	159	140	19	24/2/04			25-28	,,	About 25%	Blue mud
,, 3	359	243	116	25/2/04			28-31	,,	,, 10%	
,, 4	247	161	86	26/2/04	At mouth of Firth of Forth (inside territorial waters)		24-25	,,	,, 25%	Grey sandy mud
,, 5	176	151	25	4/3/04			24-27	,,	,, 25%	Soft mud
,, 6	41	37	4	16/3/04			64-73	,,	All	Rocky bottom
,, 7	63	25	38	24/3/04			28-29	Small trawl	,,	Muddy
Lot A. Total	**1051**	**762**	**289**							
	753	724	29					Ordinary + Small mesh	About 98%	
	54	47	7						,,	
Lot B. Total	**807**	**771**	**36**	17/1/07	Burghead Bay	6° 74–6°·2C.	20-25		All	Muddy
	353	331	22					Ordinary + Small mesh	,,	
	19	10	9						,,	
	38	20	18					Small trawl	,,	
Lot C. Total	**410**	**361**	**49**	20/4/07	Burghead Bay	6°·01–6°·4C.	28-30			1 "berried" female
	94	90	4					Ordinary + Small mesh		
	0	0	0							
Lot D. Total	**94**	**90**	**4**	26/4/07	Moray Firth	6°–6°·5C.	49-52		All	5½ hours' trawl
Lot E. Total	**238**	**232**	**6**	20/9/07	Firth of Forth	11°·07–11°·7C.	13-15	Ordinary	,,	Soft
Lot F. Total	**181**	**173**	**8**	10/10/07	,,	11°·08–11°·3C.	12-14	,,	,,	Soft mud
	585	527	58					Ordinary + Small mesh		
	145	93	52							
Lot G. Total	**730**	**620**	**110**	8/10/07	Firth of Forth	11°·25–11°·1C.	12-13		All	Sandy mud
Lot H. Total	**1024**	**933**	**91**	11/10/07	,,	11°·04–11°·3C.		Ordinary	About 80%	5 "berried" females
Grand Total	5894	5191	703							

difficulty in Dr Marshall's case is to know to what extent, if at all, boxfuls sent to the Laboratory are *selected* material, since they are bought at Newhaven fish-market. The same difficulty applies to the 1359 "Zool. Lab." specimens which are here dealt with, and an examination of the numbers in the different boxes shows how variable is the proportion of the sexes. There were altogether 110 females in this collection, or just over 8·2 per cent., compared with Dr Marshall's 6·4 per cent. Yet the percentages in the different boxfuls varied from less than 1 to nearly 14. On the whole, however, the results are fairly consistent. But there does not seem, at least at first glance, to be much consistency in the proportion of the sexes in many of the lots outside the University collections. And yet we are here surer of our facts, since we know that these specimens at least (lots A to H) were taken at random.

It is when we examine the total number of (*a*) males and (*b*) females in (1) catches taken by the ordinary trawl, and (2) catches taken by small-mesh net or by small trawl, that a possible explanation appears. From Table III. it is seen that of lots A to H, altogether 4216 *Nephrops* were captured in the large trawl, and 319 in the small-mesh net (*i.e.*, "escapes" from the large trawl) or in the small trawl. There are 469 females, or over 11 per cent., among the 4216 captured by the large trawl, against 124 females, or about 43·5 per cent., among the 319 captured by the smaller mesh nets. It is also significant that in one case, lot A, haul 7, *the females actually outnumber the males*, and that here the small trawl was used. (It is very probable that the size of the mesh, which was smaller than that in general use by trawlers, may account for my finding about equal numbers of males and females in 656 Norway lobsters dredged in the Clyde in September 1903.) From all this it may perhaps be inferred that, while, as a matter of fact, more males than females are caught, this may be accounted for partly by the method of capture, for males, being larger than females, may (1) be caught in greater numbers owing to size of mesh used, and (2) be kept by fishermen while smaller ones are rejected as unsaleable.

3. On Variation in the Number and Arrangement of the Male Genital Apertures.

For this purpose 4429 Norway lobsters were examined. It was indeed this part of the examination that led to a consideration of the two points just discussed. Dr Marshall, in the paper already referred to, says "That Norway lobsters with additional genital apertures have been common in Scottish waters for a considerable number of years, appears from information supplied me by Professor Ewart, Dr Beard, Dr Masterman, and others," and "Dr Beard, who has had occasion to examine a very large number, speaks to me of regular epidemics of this kind of abnormality in some years

Table IV.

Numbers of Abnormal Males.

Different Lots.	Total Males.	Normal Males.	Abnormal Males.	Percentage of Abnormality.
"Zool. Lab."	1249	1167	82	6·6
Lot B.	771	739	32	4·2
Lot C.	361	351	10	2·8
Lot D.	90	89	1	1·1
Lot E.	232	208	24	10·3
Lot F.	173	164	9	5·2
Lot G.	620	565	55	8·9
Lot H.	933	859	74	7·9
Total,	4429	4142	287	6·5

in the past" (page 8). In an examination in 1901 of 1000 male specimens in the Zoological Department of Edinburgh University, Dr Marshall found that 12·2 per cent. were abnormal in this respect. It was chiefly to test whether this high percentage is still maintained that the present investigation was begun, and as the 1249 "Zool. Lab." specimens here considered were procured under exactly similar conditions, the comparison is at least interesting. The results are summarised in Table IV., where it is shown

that 82, or 6·6 per cent., of these 1249 specimens were abnormal as regards their genital apertures. In addition, 205, or 6·3 per cent., abnormal males were found among the remaining 3180 examined. This gives a total abnormality of genital openings amounting altogether to almost 6·5 per cent., or 287 out of 4429 specimens. This percentage, though not so high as Dr Marshall found in 1901, is sufficiently high to be worthy of note. It may be recalled that I found 2·5 per cent. abnormal out of 319 males captured in the Clyde in 1903.

Table V. is arranged in such a way that it shows readily not only the variation for the different lots, but also the kind of variation; and for purposes of comparison Dr Marshall's results are arranged in the same manner alongside. In this Table the letters *r.* and *l.* denote the right and left sides, and counting the chelæ as the first pair of legs, the walking legs proper are named the second, third, fourth, and fifth pairs from the chelæ towards the abdomen. Thus the normal genital apertures are on the fifth and third pairs of walking legs respectively for the male and female *Nephrops.* The abnormality consists in the occurrence of *additional* genital openings, for in no case were the normal ones awanting. Nor was any abnormality observed either in the number or in the position of these apertures in the female. Even where openings were shown on both the third and the fifth pairs of walking legs, there was no doubt as to sex, for the modification in the anterior abdominal appendage was always present. In external appearance the extra apertures are very like the normal ones, although occasionally they are slightly smaller, and their relative position on the basal joints of the different walking legs is identical. It will be noted from Table V. that there are no fewer than thirteen distinct variations (B′ to N′) in the number and in the arrangement of the male genital apertures, and that although bilateral symmetry is so characteristic a feature of Arthropods, those abnormalities occur with very little regard to symmetry. This is further shown in Table VI. The total range of variation, which has come under my observation, is from the normal two apertures

Table V.

Kind of Abnormality.

Pair of Walking Legs.	A′		B′		C′		D′		E′		F′		G′		H′		I′		J′		K′		L′		M′		N′		Total Abnormality.
	r.	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	*r.*	*l.*	
2nd.																									•			•	
3rd.							•			•				•	•		•			•	•	•	•	•		•	•	•	
4th.			•			•					•	•		•		•	•	•	•	•	•		•	•	•	•	•	•	
5th.	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
Zool. Lab.	1167		20		24		1		...		26		2		1		3		3		1		...		1		...		82
Lot B.	739		11		9		...		...		10		..		...		1		1		...		...		...		...		32
Lot C.	351		2		3		...		...		4		...		...		1		...		...		...		...		...		10
Lot D.	89		...		1		...		...		...		...		...		...		...		...		...		...		...		1
Lot E.	208		7		6		...		...		6		1		1		1		2		...		...		...		...		24
Lot F.	164		...		5		...		...		4		...		...		...		...		...		...		...		...		9
Lot G.	565		13		21		1		1		15		2		1		...		1		...		...		...		...		55
Lot H.	859		21		15		1		...		30		1		...		2		2		1		1		...		...		74
Total,	4142		74		84		3		1		95		6		3		8		9		2		1		1		0		287
Dr Marshall's Results.	878		31		40		0		1		40		1		1		2		3		0		2		0		1		122

Table VI.

Numbers with Additional Apertures.

Number of Apertures.	Arrangement of Apertures: Table V.	Zool. Lab.	Lot B.	Lot C.	Lot D.	Lot E.	Lot F.	Lot G.	Lot H.	Total.	Dr Marshall's Results.	Grand Total.
2	A′ (normal)	1167	739	351	89	208	164	565	859	4142	878	5020
3	B′ C′ D′ E′	45	20	5	1	13	5	36	37	162	72	234
4	F′ G′ H′	29	10	4	...	8	4	18	31	104	42	146
5	I′ J′ K′	7	2	1	...	3	...	1	5	19	5	24
6	L′ M′	1	...	...	...	...	...	...	1	2	2	4
7	N′	...	...	...	...	...	...	...	...	0	1	1
Total Abnormality,		82	32	10	1	24	9	55	74	287	122	409

up to six apertures, though Dr Marshall found a single example with seven openings. The eleventh and twelfth columns of Table VI. show how continuous is the series when account is taken of the number of openings, irrespective of their arrangement. The absence of symmetry in both arrangement and number is very marked. No correlation could be traced between the number of genital apertures and any organ. It is desirable to discuss the nature and origin of these additional openings in a separate paper.

The conclusions may now be summarised as follows:—

1. That the occurrence of additional genital apertures is by no means uncommon (Table IV.).
2. That the abnormal genital openings occur without any regard to bilateral symmetry (Table V.).
3. That, as one would expect, the number of examples showing abnormality decreases as the extent of the abnormality increases (Table VI., columns 11, 12, and 13).

It remains for me to give my best thanks to Professor J. Cossar Ewart and to Dr Ashworth for their kindness in allowing me to examine the stock of Norway lobsters in the Zoological Laboratory of Edinburgh University, and for granting facilities for the working up of the data; to Dr Marshall, of the Physiological Department of Edinburgh University, at whose suggestion the inquiry was originally begun; and to Mr Alexander Bowman, B.Sc., of the scientific staff of the North Sea Investigation International Board, who has not only supplied me with much material, but has assisted me in arranging the various data.

XI. *A large Tubularian* (Tubularia regalis, *Boeck*) *from the Moray Firth.* By Prof. J. Arthur Thomson, M.A.

(Read 16th December 1907.)

On 23rd March 1907, the "Goldseeker," engaged in the international scientific exploration of the North Sea, dredged from a depth of 39 fathoms in the Moray Firth (58° N., 2° 38′ W.) a magnificent colony of a species of *Tubularia,* which seems to be an addition to the list of British Hydroids. Through the kindness of Prof. D'Arcy W. Thompson, C.B., I obtained the specimen for examination, and my conclusion is that it is referable to *Tubularia regalis,* described in 1859 from Spitzbergen by Chr. Boeck.

The beautiful cluster of polyps is about a foot in height, and strikes one at once as larger and more substantial than similar clusters of the common *Tubularia indivisa,* which it resembles in general colouring. The height of a single hydrocaulus, measured apart from the interlaced tangle at the base, varies from 7-10 inches, and to this the large hydranth may add nearly another inch (20-22 mm.). The breadth of the hydrocaulus is about 3 mm., and the largest hydranth at its broadest part has, in the contracted preserved state, a width of about 20 mm. There are 12-15 longitudinal lines on the clear perisarc, corresponding to vermilion lines on the cœnosarc which shine through.

There are 32-36 proximal tentacles from 12-22 mm. in length, and the maximum spread of the tentacles, measured along a diameter of the circle which they form, is about 60 mm. The distal tentacles form a dense brush, consisting of several close tiers around the mouth. From 76 to 92 were counted on various hydranths. Each distal tentacle is about 4 mm. in length, 0·4 mm. across the base, tapering to 0·1 mm. at the tip.

Immediately above the bases of the proximal tentacles, 12 to 14 unbranched blastostyles or pendulous racemes

of gonophores are inserted. They hang down, regularly interpolated, among the proximal tentacles, which they equal in length (12-22 mm.). On several of these pendulous racemes, 48 gonophores were counted. The gonophores are oval in form, with average diameters of 1 mm. and 2 mm. Some of them show a very long spadix, but there is no trace of radial canals.

The question of present interest is, To which species of *Tubularia* does this magnificent Moray Firth specimen belong? We may at once dismiss the small species, such as *T. larynx* and *T. bellis,* and confine our attention to those which are often or usually over 6 inches in length, namely, *T. regalis,* Boeck, *T. indivisa,* L., *T. variabilis,* Bonnevie, and *T. insignis,* Allman.

Taking the last first, we find that, according to Allman, the hydrocaulus of *T. insignis* attains a height of 7 inches or more. Indeed, the monographer notes that "it far surpasses in size every British representative of the genus." But the hydrocaulus of our Moray Firth specimen may attain a height of 10 inches. The hydranth of *T. insignis* (which was found at Dieppe) was about half an inch in height from base to summit, but several hydranths in our specimen originally stood up for nearly an inch. We mention these facts to emphasise the large dimensions of our specimen. We need not, however, delay over *T. insignis,* for besides differing markedly as regard its tentacles, it is removed from any close systematic proximity to our specimen by more important differences relating to the blastostyles. In *T. insignis* the blastostyles are "in six or seven imbricated verticels, with about twenty in each verticel, not pendulous," whereas our specimen has 12 to 14 pendulous blastostyles.

The next on the list is the large *T. variabilis,* Bonnevie, which has a height of 100-300 mm., distinct longitudinal striping, 25-35 proximal tentacles (15-20 mm. in length), 10-20 blastostyles (20 mm. in length), and is thus in many respects like our specimen. But it again may be left out of account, since its gonophores are characterised by 3-6 high external ribs corresponding to a similar variable number of

radial canals, whereas the gonophores of our specimen have no ribs and show no radial canals. For similar reasons, we need not consider either *T. asymmetrica*, Bonnevie, or *T. obliqua*, Bonnevie, which have rudimentary tentacles on the gonophores.

Is it then possible that the Moray Firth specimen is simply a very large and luxuriant representative of the common *T. indivisa*, perhaps like the vaguely known *T. gigantea* of Lamouroux, which attained a height of 12-15 inches, and was regarded by Allman as "probably only a large form of *T. indivisa*"? If the radial canals are absent from the gonophores of the Moray Firth specimen, as they appear to be, then it cannot be identified with *T. indivisa*, whose gonophores have four radial canals; but it seems undesirable to press this point, since our specimen has not been adequately fixed. The difficulty of deciding whether our specimen is or is not referable to *T. indivisa* is complicated by the fact that there are considerable differences between Allman's and Hincks's descriptions. The real difficulty is that we cannot judge as to the specific value of numerical and quantitative differences without examining a large number of specimens, which we have not, as yet, been able to do.

It may be pointed out that the difference between Allman's "40 distal tentacles" and our 76-92 is very considerable, but Hincks simply says "very numerous." Similarly, the difference between Allman's "3 or 4 pendulous racemes of gonophores" and our 14 is also very considerable, but again Hincks says "numerous." On the whole, however, the numerical and quantitative differences seem to warrant us in separating our specimen from *T. indivisa*, and it seems to us that it should be referred to Boeck's Spitzbergen species, *T. regalis*.

In contrasting *T. indivisa* and *T. regalis*, Miss Bonnevie notes that the former has 4 radial canals on its gonophores, while the latter has none; that the former has 20-30 proximal tentacles, about 10 mm. in length, while the latter has 20-30, 20-40 mm. in length; that the former has 3-10 blastostyles, while the latter has 10-20, 35 mm. in length.

Our specimen resembles *T. regalis* (1) in having bright red longitudinal lines on the cœnosarc, which are seen shining through the clear perisarc; (2) in the breadth of the hydrocaulus (3 mm.); (3) in the great height and breadth of the hydranth; (4) in the length of the proximal tentacles (up to 22 mm.); (5) in the length of the distal tentacles (3-4 mm.); (6) in the shape and arrangement and length of the blastostyles; (7) in the long spadix within the gonophores; and (8) in showing no trace of radial canals.

Our specimen differs from *T. regalis*, as described by Boeck, (1) in having 32-36 proximal tentacles instead of 28, but Bonnevie says 20-30; (2) in having shorter proximal tentacles and blastosyles, 12-22 mm. instead of 42-45 mm., but Bonnevie gives 20-40 mm. as the length of the tentacles and 35 mm. as the length of the blastostyles. It should also be noted that our specimen was considerably contracted by preservation before the measurements were taken. Boeck figured the blastostyles as if they stood up vertically, but Allman pointed out that this position is impossible.

Before giving a tabular comparison, which will show the resemblances and differences at a glance, we may supplement the descriptions of *T. regalis* by a reference to the hydrorhiza, which was absent in the specimens obtained by the Norwegian North Atlantic Expedition, and was left unnoticed by Boeck. As Miss Bonnevie supposed, the lower part of the hydrocaulus is composite, as in *T. indivisa*. The stems are twisted together in a tangle at the base. It may also be noted that one hydrocaulus bears a small barnacle, *Scalpellum vulgare.*

Species.	Hydrocaulus.	Hydranth.	Proximal Tentacles.	Distal Tentacles.	Blastostyles.	Gonophores.	
T. indivisa (as described by Allman).	Ht. 76–226 mm. Br. 2·5 mm.	....	20–30.	40.	3 or 4 pendulous racemes, surpassing the hydranth in length.	Oviform, without tentaculiform tubercles; 4 radial canals.	
T. indivisa (as described by Hincks).	Ht. 150–300 mm.	....	About 40.	Very numerous.	Gonophores on branched peduncles, forming large and very numerous clusters.	With four radiating canals, and four small tubercles at their terminations.	
T. indivisa (as summed up by Bonnevie).	Ht. 100–300 mm. With longitudinal striping, no collar.	....	20–30, about 10 mm. long.	Several circles, very close together; 2–3 mm. long.	3–10, male longer than female	No tentacles; 4 radial canals.	
T. regalis (as described by Boeck).	Ht. 120–130 mm. Br. over 3 mm. With longitudinal bright red stripes.	18 mm. in height.	28, 42–45 mm. in length, with a maximum spread of 80–85 mm.	Very numerous; 3–4 mm. in length.	Simple racemes, equal in length to the proximal tentacles, and alternating with them.	Oviform, without tentaculiform tubercles, with a long spadix.	Near Spitzbergen.
T. regalis (as described by Bonnevie).	Ht. 100–300 mm. With longitudinal striping, no collar. The actual stems measured were over 200 mm. in length.	Hydranths measured from 7 to 9 cm. beyond [across?] the proximal tentacles.	20–30, 15–40 mm. long; also stated as 20–40 mm. long.	Several circles, very close together; 2–3 mm. long.	10–20; length 35 mm., in a circle just within that of the proximal tentacles.	No tentacles; no radial canals.	72° 27′ N., 20° 51′ E.; 349 metres. 76° 34′ N., 12° 51′ E.; 1359 metres.
The Moray Firth Specimen.	Ht. 175–250 mm. Br. 3 mm. With about 15 bright red lines on the cœnosarc shining through the clear perisarc.	20–22 mm. in height; 20 mm. in maximum breadth.	32–36, 12–22 mm. in length, with a maximum spread of about 60 mm.	76–92; 4 mm. in length.	12–14 pendulous simple racemes, 12–22 mm. in length.	Oviform, without tentacles; apparently without radial canals; with a long spadix.	58° N., 2° 38′ W.; 39 fathoms.

The results of this short note on a very beautiful specimen may be summed up in a sentence. There exists in the Moray Firth a large species of *Tubularia*, differing considerably from the familiar *T. indivisa*, and closely resembling *T. regalis*; if it be referred to the latter, as seems justifiable, a new record is made for British waters, and a distinctively northern form, previously recorded from near Spitzbergen and from far to the north of Norway, is shown to have an interesting extension of its range southwards.

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XII. *Notes on Fossils from Prince Charles Foreland, brought home by Dr William S. Bruce in* 1906 *and* 1907. By G. W. Lee, D.Sc., *of H.M. Geological Survey of Scotland.* [Plate VIII.]

(Read 23rd March 1908.)

In the summers of 1906 and 1907, Dr W. S. Bruce made a topographical survey of Prince Charles Foreland, under the auspices of His Serene Highness the Prince of Monaco; and whilst engaged in this work he collected many interesting geological specimens. A great number of these had, however, through an unfortunate mishap, to be left behind, so that the material actually brought home is rather scanty; but as apparently it is sufficiently representative of the main types collected, Dr Bruce has been good enough to afford me the privilege of studying his unique collection.

Although the main islands of Spitsbergen have been the subject of numerous geological investigations, practically nothing was known of the geology of Prince Charles Foreland till Dr Bruce made some discoveries which led him to the belief that, contrary to the opinions expressed by the few geologists who have visited the spot, the island is not wholly made up of the Lower Palæozic strata known as the "Hecla-Hook" Series, but contains more recent formations.[1]

The study of the fossils submitted to me fully confirmed Dr Bruce's surmise, so that the collection, scanty as it is, is very important as a starting-point for future investigations.

The present preliminary note is based on the examination of the following material:—

I. A suite of crystalline schists, quartzites, black papery shales, barren grey limestone, sandstones, and conglomerates, etc.

This suite is probably the equivalent of the "Hecla-Hook" Series of Spitsbergen, but as no fossils have been found in the specimens available, its correct age cannot be determined at present. As the sequence and the exact relationships of the various members of the suite are not accurately known, the detailed description of the latter will

[1] See *Scottish Geog. Mag.* for March 1907—"Prince Charles Foreland," by Dr W. S. Bruce.

find a better place elsewhere in connection with the topographical description of the island.

II. Large blocks of a black fossiliferous limestone, hard and crystalline, and containing an abundance of carbonaceous matter.

The most conspicuous fossil here is a large Bryozoon belonging to the genus *Stenopora;* the other fossils are all Brachiopoda, and although scarce, attain a large size. This rock was found *in situ* in the low ground that separates the main mountain range from the isolated peak at the S.E. end of the island, known as Saddle Mountain. The exact geological age of this rock cannot be inferred from the fossils, as they may be either Carboniferous or Permo-Carboniferous.

III. A fragment of a whitish-grey siliceous limestone, friable on the decomposed surface, compact where fresh.

The specimen is apparently a fragmentary cast of a large Cephalopod, within which are many smaller fossils. This was found in the same locality as No. II., but not *in situ.* Upper Carboniferous (?).

IV. Two blocks of a grey, siliceous, and highly fossiliferous limestone, having when weathered a yellow surface, crowded with the remains of Fenestellid Bryozoa.

The rock is extremely hard and compact, but not crystalline. It is a very good example of a "*Bryozoa Reef*," and contains many other fossils besides Bryozoa. Its locality is the same as given above, but it was not found *in situ.* Dr Bruce, however, believes that its outcrop can be traced along the southern part of the western coast of the island. Permian.

V. Slabs of hard grey shale, containing remains of dicotyledonous leaves of Tertiary age.

Of these, the best specimens have been examined by Professor Nathorst, the authority on the fossil flora of the Arctic regions, who states that "they must have been collected from the lower plant-bearing horizon at the base of the Tertiary Series." He adds that he will examine the specimens more closely, and send further information about them.

Found *in situ* in the northern part of the east coast and at Peter Winter's Bay.

The description—following the above order—of the fossils obtained from Groups II., III., and IV. will now be given, but before doing so a few words may be said about the literature of the subject. With the exception of Dr Bruce's paper alluded to, no reference has ever been made to fossils having been found in Prince Charles Foreland, but as this island is very close to Spitsbergen, the literature dealing with the latter has been freely made use of. A full list of the numerous works on the stratigraphy of Spitsbergen would fill many pages, so that reference will be made in the text only to papers that have a direct bearing on the particular subject under investigation. I may add that a very comprehensive summary of our knowledge of Spitsbergen, with full bibliography up to the year 1894, has been published by Messrs Ramond and Dollfus in the *Feuille des Jeunes Naturalistes* for October 1894, whilst more recent contributions will be found in works by Messrs J. Gunnar Anderson, Frech, Nathorst, Tschernyschew, etc.

Black Limestone (No. II.).

BRYOZOA.

STENOPORA, Lonsdale.

Stenopora, Lonsdale in Darwin's Geol. Obs. Volc. Islands, 1844, p. 161.
,, Lonsdale in Murchison's Geol. of Russia, 1845, pp. 221 and 631 (pars), Plate A, Appendix A, fig. 12 (*non* fig. 11).
,, Nicholson and Etheridge, jun., Ann. Mag. Nat. Hist., 1879, iv. p. 265.
,, Nicholson, Tab. Corals Pal. Period, 1879, p. 168.
,, Nicholson, Genus Monticulipora, 1881, p. 81.
,, Ulrich, Jour. Cincinnati Nat. Hist. Soc., v., 1882, p. 154.
,, Waagen and Wenzel, Pal. Indica, Salt Range Fossils, 1886, vol. i. part 6, p. 885.
,, Ulrich, Geol. Surv. Illinois, viii., 1890, pp. 375, 436.
,, Romanowsky, Verhandl. russ. min. Gesell., Bd. 28, 1891, p. 169, pl. vi.
,, R. Etheridge, jun., Mem. Geol. Surv. N. S. Wales, 1891, Palæontology, No. 5, p. 32.
,, Nickles and Bassler, U. S. Geol. Surv. Bull., No. 173, 1900.

The above synonymy, in which only a few of the better characterised descriptions are quoted, could have been made

much more comprehensive, but its sole object is to indicate the exact signification of the generic name here employed, and the authorities followed. This explicitness is all the more necessary, for the reason that *Stenopora* is, on the one hand, represented in the collection by a large number of specimens belonging to species that I consider to be new, whilst, on the other hand, fossils from Spitsbergen, Nowaja Semlja, and Northern Russia have been described under that name; and, as will be shown below, it is possible that the latter belong, in part, to other members of the family Batostomellidæ.

Stenopora brucei, n. sp.

(Plate VIII. Figs. 1, 2, 3, 4, and 5.)

Zoarium ramose and dichotomous; branches cylindrical, never compressed, of an average diameter of 10 mm. The largest specimen observed must have exceeded 10 cm. in height, with a maximum diameter of 12 mm. The decrease in the size of the diameter towards the apex is small, but somewhat variable, some branches tapering more rapidly than others. The base of attachment has not been met with, but nothing has been observed that would lead one to suspect that the dichotomous stems are offshoots of more massive zoaria. Surface even, showing neither monticules nor maculæ. Zoæcial apertures subcircular, separated by very thin interspaces—about three apertures can be counted within the space of 1 mm. Nearly every junction angle between the apertures shows the blunt projection of an acanthopore. On longitudinal fractures the zoæcial tubes are seen to proceed in a gentle curve to the surface, to which they are perpendicular for a distance of a little over $1\frac{1}{2}$ mm. About thirty of these may be counted within 1 cm. With the aid of a low-power lens, or even with the unaided eye, one can easily observe in the peripheral region the periodical constrictions of the casts of the tubes corresponding to the moniliform swellings of the walls.

Microscopical Examination.—The walls of the zoæcia are

very thin in the axial region; and from that point of their course where they begin to be perpendicular to the surface, they are suddenly thickened to a considerable degree, and exhibit the moniliform structure characteristic of the genus. The swellings, separated by thin intervals, are oval in shape, and not numerous. In one case it has been possible to observe the divisional line between adjoining zoæcia.

Although a number of thin longitudinal sections of both axial and mature regions has been prepared, on none has it been possible to observe the presence of diaphragms; and as the specimens are all in a very good state of preservation, it follows that the absence of diaphragms cannot be attributed to the action of weathering, but that it is one of the specific characters of this *Stenopora.*

Tangential sections near the periphery show the presence of large acanthopores at most of the junction angles between adjoining zoæcia. The structure of the concentric lamellæ, of dark sclerenchyma, and the minute axial canal of the acanthopores, are well preserved. An immature zoæcium generally accompanies each of the larger ones.

Remarks.—In this species the branches are always simple, that is, never formed of successive colonies in concentric layers. In one particular specimen the colony is seen to envelop a foreign body, probably a *Serpula,* which occupies the middle of the longer axis of the colony. According to Messrs Waagen and Wenzel,[1] this phenomenon is of frequent occurrence in colonies of *Batostomella columnaris* (Schloth.) [*Geinitzella auctt.*], and was erroneously considered by Dybowski[2] to be an essential character of the genus "*Stenopora.*" These authors give excellent figures of thin sections of *Batostomella columnaris,* proving the undoubtedly foreign nature of these enveloped bodies (the "*Axenrohr*" of Dybowski).

Affinities and Differences.—It is an easy matter to compare the present species with those described of late years by authors who have made use of modern methods of investigation. The absence of diaphragms distinguishes it from all

[1] *Pal. Indica, Salt Range Fossils,* part 6, "Cœlenterata," p. 880.

[2] *Verhandl. russ. Kais. min. Gesel.,* Zweite Ser., 12 Band, 1877, p. 65.

the species described from Europe, India, and Australia. Doubtless two of the American species described by Dr E. O. Ulrich are without diaphragms (viz., *S. angularis* and *Stenopora* (?) *signata*), but this is the only resemblance, the other characters being quite different.[1]

The same remark applies to *S. spissa,* Rogers,[2] another form in which the diaphragms are absent. Apart from this absence of diaphragms, reference to the figures given here shows that the other structural features, such as the shape, the size, and number of the swellings of the walls, etc., are quite characteristic.

Comparison with the species of *Stenopora* (?) described by the older authors is much more difficult, as there is only the external appearance to go by. Of the two species described from Russia by Lonsdale, "*Stenopora*" *spinigera* is placed by most authors in the genus *Geinitzella,* Waagen and Wenzel (now *Batostomella,* Ulrich). This is probably its correct position, as, according to Lonsdale's description, the walls do not exhibit the moniliform structure characteristic of the genus, or rather, he did not observe the corresponding contractions of the tubes. *S. crassa* has also been removed to the genus *Geinitzella*[3] by some palæontologists, but in this case there seems to be nothing to prove the non-validity of the generic attribution of the species, as Lonsdale distinctly says in his diagnosis of the species, that "contractions are occasionally visible in the bent portions" [of the zoæcia],[4] and on Fig. 12 *a* of the accompanying plate there is an undoubted attempt at showing them. It is necessary to give these details, as the external characters of *S. brucei* bear some resemblance to those of *S. crassa,* Lonsdale; but the former differ from the latter in having twice as many zoæcia, and a more distinctly differentiated mature region.

In 1875 Professor Toula described from the Permo-

[1] *Geol. Surv. Illinois,* vol. viii. pp. 439, 446, 1890.

[2] *Kansas University Quarterly,* Ser. A, Jan. 1900.

[3] Waagen and Wenzel, *loc. cit.,* p. 884. See also A. Stuckenberg, "Die Korallen und die Bryozoen der Steinkohlen-ablagerungen des Ural und des Timan," *Mem. du Comité Géol. de Russie,* vol. x., 1895, p. 227.

[4] *Murchison's Russia,* p. 632, Plate A, figs. 12, 12 *a.*

Carboniferous formation of Spitsbergen a fossil which he identified with "*Stenopora*" *ramosa*, Geinitz.[1] [2]

It has since been proved by Messrs Waagen and Wenzel (*loc. cit.*, p. 882) that Geinitz's species does not belong to Lonsdale's genus, and it is for the reception of this species, and others of the group of "*Stenopora*" *columnaris* (Schloth.), that they established the genus *Geinitzella*, which is now considered to be a synonym for *Batostomella*, Ulrich, a genus established four years previously by Dr E. O. Ulrich on the basis of similar characters.[3]

Too little is known of Professor Toula's species to judge of its true affinities. It resembles *S. brucei* in the fact that it forms branching zoaria exhibiting a well-differentiated mature region; it also approaches it in size, being as much as 13 mm. in diameter; but, on the other hand, it sometimes forms colonies of concentric layers, and appears not to possess the moniliform wall-structure of *Stenopora*. Professor Toula does not make any mention of that character, which, moreover, is not shown in the enlarged figure, 3 *b* (Tab. X., *loc. cit.*). On such large zoaria, constrictions of the tubes corresponding to swellings of the walls, would, if present, have been detected with the aid of a lens. It would thus appear that Messrs Waagen and Wenzel were right when they removed *Stenopora ramosa*, Toula, to their genus *Geinitzella*.

BRACHIOPODA.

Strophomenidæ.

? *Orthotetes* or ? *Derbya*, sp. indet.

A large Strophomenid is represented by numerous fragments, and one or two complete brachial valves; some of the fragments belong to shells which must have measured quite four inches in length. Unfortunately, no sufficiently well-

[1] "Permo-Carbon Fossilien von der Westküste von Spitzbergen," *Neues Jahrbuch*, 1875, p. 246, Tab. x. figs. 2, 3.

[2] Geinitz, *Dyas*, p. 114.

[3] "American Palæozoic Bryozoa," *Jour. Cincinnati Nat. Hist. Soc.*, 1882, p. 154.

preserved pedicle-valves are in the collection, so that the presence or the absence of a median septum cannot be ascertained; it is therefore not possible to say, with certainty, whether we are dealing with a *Derbya* or with an *Orthotetes*. So far as external characters can be trusted, it appears to be closely allied to, if not identical with, the form described as "*Streptorhynchus crenistria*" (Phill.) by Professor Toula.[1] In common with it, the brachial valve, broad and convex, has a shallow median depression, and its ornamentation is the same.

Spiriferidæ.

Reticularia, M'Coy.

?*Reticularia lineata* (Martin).

This determination is based on the external characters of one specimen only, but as both the shape and the ornamentation of the shell are quite typical, little doubt need be entertained as to the validity of the identification.

Productidæ.

Marginifera, Waagen.

Marginifera, sp. indet.

A large Productoid shell, four inches in width from wing to wing, is to be referred to this genus. Although too imperfectly preserved to justify a specific determination, it exhibits the generic character distinctly enough. The brachial valve being much corroded and partly broken, the shelly ridges or shelves situated within the wings in the pedicle-valve are exposed to view; the brachial valve is too weathered to show the corresponding ridges along the shell margin.

This form is characterised by a very much inflated pedicle-valve, forming a regular spiral curve in the longitudinal direction. The apex is prominent, and near it there begins

[1] "Kohlenkalk Fossilien von der Südspitze von Spitzbergen," *Sitzb. K. Akad. Wiss. Wien.*, Math. Nat. Cl., lxviii. Bd., 1873.

an extremely deep sinus, which extends down to the front. The ratio of width to height is about 4:2·5. Shell substance very thick (3 mm.); ornamentation not known, but there are faint indications of reticulation on the slightly concave brachial valve.

As regards its affinities, this form should probably be placed in the group of *M. typica*, Waagen, but it is much larger than the latter, and its visceral part is not so elevated above the hinge-line; the shell substance is also much thicker.

The genus has already been recorded from the Arctic regions by Professor Tschernyschew. In the Table, p. 360 of his work on the Brachiopods of the Ural and Timan, *M. typica* var. *septentrionalis*, Tschern., is indicated as present in the "Spirifer Limestone" of Spitsbergen and the Bear Islands; it is therefore interesting to note the occurrence in these regions of what may prove to be another species of this genus.

Genera Indeterminable.

Rhynchonellids and (?) Athyrids are present, but only as fragments, so that they cannot be determined, even generically, but they are mentioned here in order to give a complete idea of the fossils collected.

The fragment of whitish-grey siliceous limestone (No. III.), apparently the cast of a large *Actinoceras*, yielded the following fossils:—

Fusulina cf. *cylindrica*, Fischer.
Calicinal cast of Zaphrentoid coral.
Casts of Crinoidal stems.
Cf. *Chonetes buchiana*, de Kon.

Of these fossils, the most interesting, from a stratigraphical point of view, is *Fusulina* cf. *cylindrica*. Although not quite identical with the characteristic form of the species as described by Fischer de Waldheim, its occurrence in Prince Charles Foreland is rather important, as it may prove useful for correlation purposes. In 1882 Messrs Nathorst

and de Geer collected in Spitsbergen a *Fusulina*, which was subsequently determined as *F. cylindrica* by Mr A. Goes;[1] it was also collected in the Bear Island in 1898, and made use of as a zonal fossil by Mr J. Gunnar Anderson in his paper on the geology of that island.[2] On the other hand, according to Professor Tschernyschew, to whom Mr Anderson's specimens were submitted, this Bear Island *Fusulina* is more closely allied to *F. montipara* (Ehrenberg).[3]

The Prince Charles Foreland form differs from the common Russian one, as delineated by Fischer, in being slightly more swollen, that is, it bulges more in the median region, and tapers more rapidly towards the apices; in this respect it is very similar to the more inflated specimens figured by Mr Goes (*loc. cit.*, p. 35). As an appreciable range of variation appears to obtain in the Arctic species, the few specimens at hand cannot be considered sufficiently representative to enable one to establish its true affinities; all that can be said at present is that the Prince Charles Foreland *Fusulina* is probably identical with that found in Spitsbergen and the Bear Island.

Grey "Bryozoa Limestone" (No. III.).

VERMES.

Spirorbis, sp. indet.

The casts of two specimens of *Spirorbis* (2 mm. in diameter) were found attached to the weathered surface of the limestone. They are very similar to the flat, umbilicated form described as *S. permianus* by King.[4]

[1] "Om *Fusulina cylindrica* Fischer fran Spetsbergen," *Ofvers. Vet. Akad. Förhandl.*, 1883, No. 8, pp. 29-35.

[2] *Bull. Geol. Inst*, Upsala, 1899, No. 8.

[3] See Appendix to Mr Anderson's work; and Professor Tschernyschew's monograph of the Russian Brachiopoda, p. 688. Also, "Nyare litteratur om Beeren Eilands geologi," by J. Gunnar Anderson, *Geol. Fören. Förhandl.*, No. 207, 1901.

[4] *Permian Fossils of England*, plate vi. figs. 12, 13.

CRUSTACEA.

Trilobita.

Phillipsia, sp. indet.

The occurrence of Trilobites in the Permian limestone of Prince Charles Foreland is indicated by a fragment of pygidium, and the obscure cast of the cephalic shield of a *Phillipsia*. The pygidium has a strongly defined trilobation; the mesial lobe, very prominent, is wider than the lateral lobes (not including the width of the margins); the margins are broad and apparently not ornamented. The segments, the number of which is not known, are separated by deep furrows, and terminate abruptly at the inner edge of the marginal zone.

Although a specific determination cannot be given, it is extremely interesting to note the occurrence of a Trilobite in a bed of Permian age in these regions. So far as I am aware, Permian Trilobites are very rare in Europe, and this record from a new locality is a point worth mentioning.

? Ostracoda.

Pending further investigation, it may be stated that remains of what appear to be the carapaces of some large Ostracod occur sparingly, but the material is so meagre that it must be left unclassified till undoubted specimens are obtained.

BRYOZOA.

Trepostomata.

STENOPORA, Lonsdale.

Stenopora cidariformis, n. sp.[1]

(Plate VIII. Figs. 6 and 7.)

Zoarium slender, ramose, dichotomous; branches always cylindrical, from 4 to 7 mm. in diameter, with very little

[1] Thus named from the resemblance that tangential sections bear to the test of *Cidaris*.

tapering towards the apex. Base of attachment not known. Surface without monticules or maculæ. Zoæcial apertures subcircular, separated by thin interspaces, from twenty-five to twenty-seven in the space of 1 cm. The interspaces are occupied by two sets of acanthopores; a relatively large acanthopore can generally be seen at the junction angles, whilst smaller ones, numerous and regularly distributed, surround the zoæcial apertures. As seen on longitudinal fractures, the zoæcia, in the mature region, are perpendicular to the surface, but that portion of their course does not exceed 1 mm. in length. Constrictions corresponding to swellings of the walls are visible with the aid of a lens.

Microscopical Examination.—Walls thin in axial region, but very much thickened in the mature one; the swellings, numbering only five or six, have a somewhat conical shape, the base of the cones being parallel to the periphery. Tangential sections show a large acanthopore at the junction angles between the zoæcia, which are also surrounded by a ring of smaller acanthopores. The latter are not so sharply defined as the larger ones, that is, their shape is not so perfectly cylindrical. No diaphragms could be detected in any part of the course of the zoæcia.

Remarks.—So far as one can judge from the material at hand—which amounts to about thirty fragments—the zoarium in this species appears to be always simple, *i.e.*, not made up of concentric layers of superimposed colonies.

Affinities and Differences.—*S. cidariformis* differs from *S. brucei* in the fact that it has two sets of acanthopores, zoæcia shorter in the mature region, with a different wall-structure, and a zoarium of more slender habit. A character that these two species have in common is the absence of diaphragms. As already stated, this feature has been observed in three American species, but the latter are otherwise quite different. *Stenopora* (?) *signata*, Ulrich, has a peculiar wall-structure, not distinctly moniliform; *S. angularis*, Ulrich, is extremely massive, with very thin walls in the mature region, whilst the species described by Mr Rogers shows no moniliform structure of the walls.

Stenopora crassa, Lonsdale, as understood by Lonsdale

himself, has a much more robust zoarium (as much as $\frac{3}{4}$ of an inch in diameter), composed of fewer zoæcia, the bent portion of which is much longer than that in the present species. The *Stenopora crassa* of subsequent authors possesses a zoarium composed of superimposed colonies, a character which is absent in *S. cidariformis*.

Stenopora, sp. indet.

(Plate VIII. Figs. 9 and 10.)

The collection contains a few fragments of a *Stenopora* characterised by an irregularly-shaped zoarium, which is partly cylindrical and partly frondescent. No complete specimen having been obtained, a definite description of the external characters of this *Stenopora* is impossible; neither is it possible to estimate the ultimate size of the entire zoarium. Of the fragments observed, the cylindrical portion attains 12 mm. in diameter, a size which must have been greater in the frondescent one.

Microscopical Examination.—In both portions of the zoarium the mature region of the zoæcia is at right angles to the axial one; but through lack of suitable longitudinal sections, the wall-structure could not be satisfactorily studied, yet it appears to be distinctly moniliform. On the other hand, an important character has been observed, viz., diaphragms are present in the outer part of the immature region, and probably also in the mature one; they are very scarce, and quite straight, with a large central perforation.

Tangential sections show rather numerous immature zoæcia, and two sets of acanthopores; those at the junction angles are very large, with a well-defined structure; the smaller ones are as in the previous species.

The different form of growth, and the presence of diaphragms, differentiate this species from the two others described in this note; but not enough is known of its characters to enable one to establish the nature of its affinities when comparing it with the other members of the genus *Stenopora*.

It should be mentioned that in 1860 J. W. Salter noticed a large foliaceous flattened species of *Stenopora* among a few Permian fossils brought home from Spitsbergen by J. Lamont in 1859;[1] but unfortunately no description is given of that species, other than the indication that it is foliaceous and flattened.

Cryptostomata.

Fenestella, Lonsdale.

Fenestella cf. *retiformis* (Schlotheim).

Fragments of a *Fenestella* occur here in immense number, but, as is usually the case with Fenestellids, the obverse face is in all specimens so firmly embedded in the matrix, that the presence and nature of the dividing ridge could not be observed. It was likewise impossible to obtain a complete frond, so that the specific determination is rather uncertain. As, however, the shape of the branches and fenestrules, and the distribution of the cells, correspond very well to what obtains in *F. retiformis* (Schloth.), I identify the present specimens with it, pending further examination on more suitable material.

Polypora, M'Coy.

Polypora is quite as abundantly represented as *Fenestella*, as regards number of specimens; but it is not possible to state whether more than one species is present, as no specimen of an entire frond is in the collection. The stronger and better preserved fragments, belonging to a frond which was apparently infundibuliform in shape, are composed of branches 1 mm. thick, longitudinally striated on the reverse side and finely granulose on the obverse side. Fenestrules elongate, four in the space of 1 cm. in the longitudinal direction, five or six within the same distance in the transverse direction. Seen from the reverse side, the fenestrules are not so elongate, and appear wider. Cell apertures in three alternating rows, with projecting margins. About thirty such apertures occur within the space of 1 cm.

[1] *Quart. Jour. Geol. Soc.*, 1860, p. 441.

More complete specimens are necessary before this form can be classified and its affinities ascertained; in its present state it cannot very well be figured, but the above description may give some idea of its nature.

? Ramipora, Toula.

The cast of a large pinnate Bryozoon is provisionally referred to this genus,[1] but as it is in a very poor state of preservation, it must be left for the present unclassified.

Remarks.—The Bryozoa described above appear to be the only ones present in the fragments of limestone under investigation. Two of these, *i.e.*, *Fenestella* cf. *retiformis* and *Polypora*, are actually rock-building organisms, and contributed to the building of this particular rock just as corals do in coral reefs. This exuberant growth of Bryozoa is similar to what obtains in various parts of the world, as for instance in the Permian rocks of South Yorkshire and Germany. It is interesting to note this similarity of conditions in countries so far apart.

BRACHIOPODA.

Productidæ.

Productus horridus, Sowerby.

This well-known fossil is represented by one or two almost perfect specimens, some of which have preserved their beautiful silvery mother-of-pearl-like test. Although none was found with the spines still attached, many of the latter occur scattered through the matrix.

The present specimens differ in no way from the typical forms of *Productus horridus* from the Permian beds of Europe, so that a description is uncalled for. On the other hand, its occurrence in the Bryozoa Limestone is very important, as it fixes the age of the latter as Permian.

An interesting comparative study of *Productus horridus* and its mutations in Spitsbergen will be found in Professor Frech's *Dyas*, pp. 497, 498.[2]

[1] *Neues Jahrbuch*, 1875, p. 230, plate x. fig. 1.

[2] *Lethaea Geognostica*, Stuttgart, 1902.

Cf. *Productus leplayi*, de Verneuil.

Productus leplayi, or an allied form, may possibly be represented by a fragmentary pedicle-valve exhibiting the type of ribbing and the scarce spines characteristic of the species.

? *Productus*, sp. indet. (2 spp. ?).

(Plate VIII. Fig. 12.)

A few pedicle-valves of a Productoid Brachiopod occur in the collection, but the cardinal region not being available for examination, their true affinities must remain doubtful. These specimens are represented by a globose type, which is figured, and by a flatter one, with less prominent beak (unfortunately not suitable for photographic reproduction). In both the ornamentation consists of numerous fine tubercles, and is strikingly like that of *Productus tenuituberculatus*, Barbot de Marny.[1]

The shape of the flatter specimens is also very similar to that of *Productus tenuituberculatus*, and in the event of the specimens under investigation being proved to belong to the genus *Productus*, they might with advantage be placed in the same group as the latter species.

Cf. *Strophalosia leplayi*, Geinitz.

(Plate VIII. Fig. 11.)

This reference to Geinitz's species is not meant to imply anything more than a mere similarity of external appearance, as neither the cardinal region nor the umbo are available in the specimens in question.

GENERA INDETERMINABLE.

Rhynchonellids appear to be represented by one or two species, the generic position of which cannot be determined in the meantime, through lack of suitable material.

[1] This comparison is based on figures of that species given by Professor Yakovlew, *Bull. Com. Géol. Russie*, tome xxiv. plate iv.

GASTEROPODA.

Gasteropoda are represented in the collection by a single dwarfed specimen belonging to *Murchisonia* or an allied genus.

CONCLUSIONS.

Reviewing the results of the palæontological evidence, we see that the age of the Black Limestone cannot be inferred from the fossils it contains; however, the presence of the genus *Marginifera* is in favour of a correlation with the Upper Carboniferous, or with the Artinskian stage of Russia. The occurrence of a *Fusulina,* apparently identical with the form found in Bear Island and Spitsbergen, in beds which Mr Anderson corraeltes, in the Appendix to his paper, with the lower part of the Upper Carboniferous formation of Russia,[1] points to the probable presence of beds of that age in Prince Charles Foreland (assuming that the fragment of rock collected by Dr Bruce is not a glacially transported one).

Productus horridus proves the presence of Permian strata in the island, and it is also interesting to note the occurrence of Bryozoa reefs similar to those which are met with in the Zechstein of Germany and the corresponding strata of Yorkshire. It is to be hoped that more material may be obtained, and that the study of a more complete assemblage of fossils from these beds will show their exact position within the Permian system, and their homotaxial equivalents in Spitsbergen and elsewhere.

Tertiary beds, with dicotyledonous plant remains, having been found *in situ* by Dr Bruce, it is permissible to infer that Mesozoic strata underlie them as in Spitsbergen, and that such may be discovered in the course of future expeditions to Prince Charles Foreland.

[1] In his second paper Mr Anderson places these beds in the upper portion of the Middle Carboniferous (*loc. cit.*, 1901, p. 222).

Explanation of Plate.

Stenopora brucei, n. sp.

Figs. 1 and 2. Two views of specimens showing mode of preservation, slightly enlarged (11/9).

Figs. 3 and 4. Peripheral portion of longitudinal sections ($\times 45$), showing wall-structure.

Fig. 5. Tangential section ($\times 45$), showing acanthopores and other features of the species.

Stenopora cidariformis, n. sp.

Fig. 6. Peripheral portion of longitudinal section ($\times 45$), showing wall-structure.

Fig. 7. Tangential section ($\times 45$), showing extremes in thickness of walls, and two sets of regularly distributed acanthopores.

Stenopora, sp. indet.

Fig. 9. Longitudinal section of outer portion of immature region ($\times 45$), showing diaphragms.

Fig. 10. Tangential section ($\times 45$), showing two sets of acanthopores and immature zoœcia.

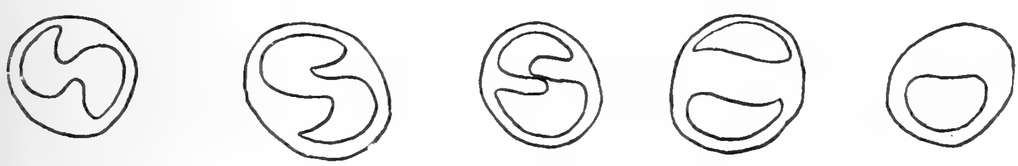
Fig. 11. Cf. *Strophalosia leplayi*, Geinitz, enlarged ($\times 1\frac{1}{2}$).

Fig. 12. ? *Productus*, sp. indet., enlarged ($\times 1\frac{1}{2}$).

XIII. *Note on the Cause of Disappearance of the Fifth Aortic Arch in Air-breathing Vertebrates.* By J. Graham Kerr.

(Read 28th October 1907.)

It is well known that there are commonly developed in the lower vertebrates a series of six pairs of aortic arches, of which the last (VI.) gives off the pulmonary artery where it is present. In the higher vertebrates, as is equally well known, there occurs typically a series of *five* pairs of aortic arches, of which the last gives rise to the pulmonary artery. The discoveries of van Bemmelen and Zimmermann showed that this curious discrepancy was more apparent than real as they found, in various amniotic vertebrates, more or less distinct vestiges of an aortic arch between the fourth and the last one, showing the latter to be morphologically the sixth aortic arch, as in the lower vertebrates. This raised a question of some interest as to what is the cause of the reduction and practical disappearance of the fifth aortic arch in the Amniota. The purpose of this note is to draw the attention of the Society to the fact that the probable answer to this question is afforded by the conditions met with amongst the Dipnoi. The adult relations of the parts concerned were clearly described by Boas for *Ceratodus* and *Protopterus*, and they may be illustrated by the condition met with in a young Lepidosiren of stage 38.



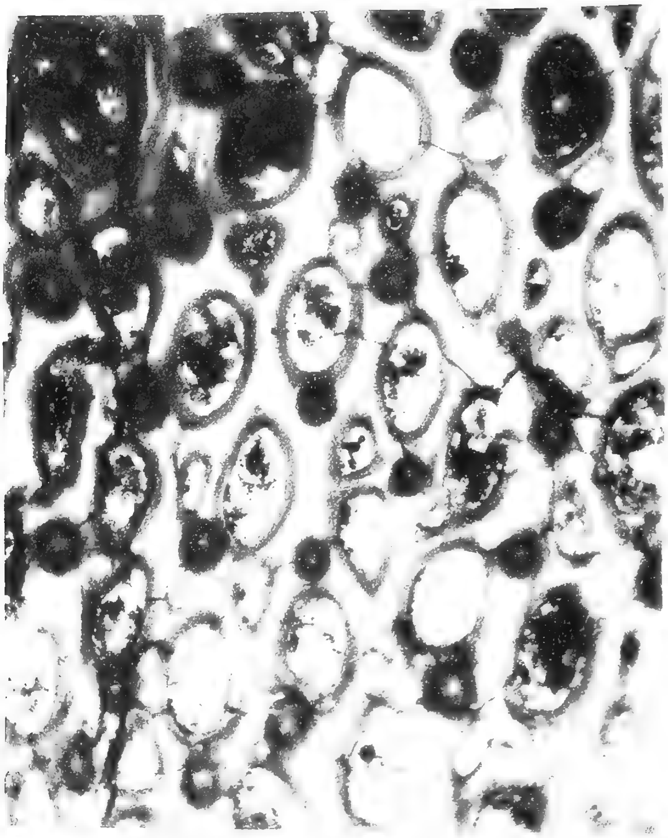
a. *b.* *c.* *d.* *e.*

Fig. 1.—Outline drawings of transverse sections through *conus arteriosus* of a young Lepidosiren of stage 38.

The text-figure shows a series of transverse sections through the *conus arteriosus* at different levels. Towards the hinder end of the conus (*a*) there are seen projecting into the

cavity the two spiral ridges, their position at this level being practically dorsal and ventral, so that they divide the lumen into two moieties, a right and a left. Sections farther forwards (*b*, *c*, *d*) show how these two chambers alter their relative position, until eventually the one which was on the right side posteriorly comes to be dorsal, while that which was on the left side comes to be ventral. The two valves have now become fused together, so as to form a complete horizontal septum, which forms the floor of the dorsal cavity. This floor, when traced forward, is seen to slope upwards towards the dorsal wall of the ventral aorta, with which it completely blends (*e*). The dorsal chamber is thus closed anteriorly. The point at which its floor meets and fuses with its roof is situated behind the point of origin of the fourth aortic arch, and in front of the point of origin of the fifth. Both fifth and sixth aortic arches arise from the dorsal side of the ventral aorta, *i.e.*, they receive their blood from the dorsal chamber.

It is the fact of the extension forwards of this dorsal chamber, so as to include the origin of the fifth aortic arch, that appears to be answerable for the reduction of this arch in the higher lung-breathing forms, for it is quite clear that increased development of the lung, as the respiratory organ, would lead to increased size of the pulmonary arteries, and it would obviously be advantageous that the pulmonary arteries should drain away a larger and larger proportion of the venous blood (from the right side of the heart) in the dorsal chamber. The fifth arch, which is dependent on the same source of supply, would thus get less and less blood, and we should therefore have every expectation that it would diminish in size and finally disappear, as has been the case in the higher vertebrates.



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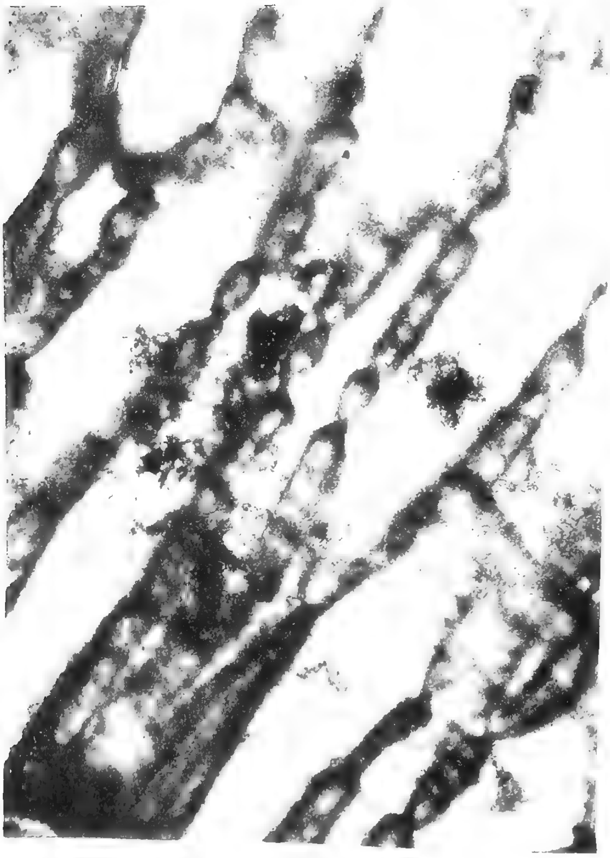

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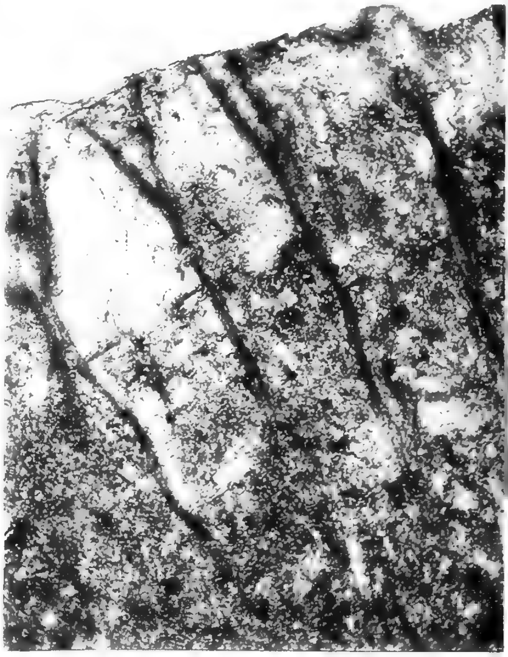

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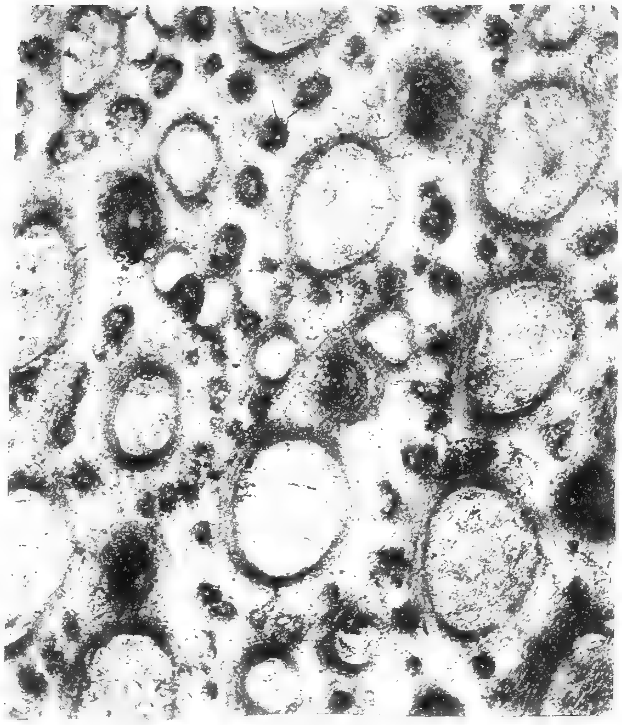

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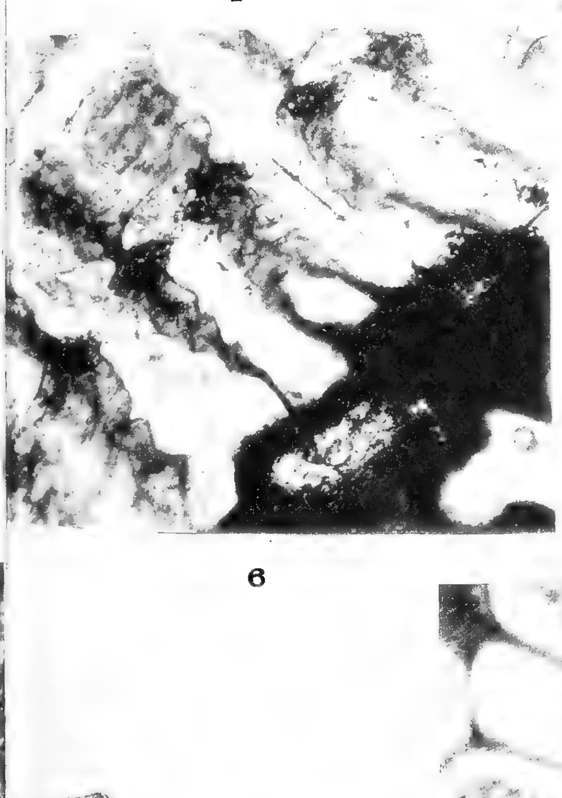

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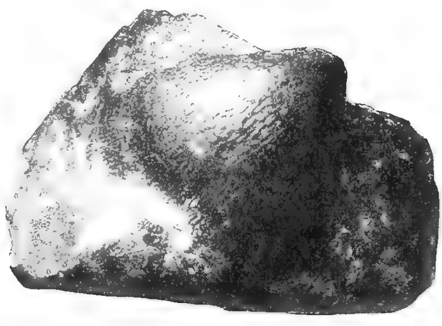

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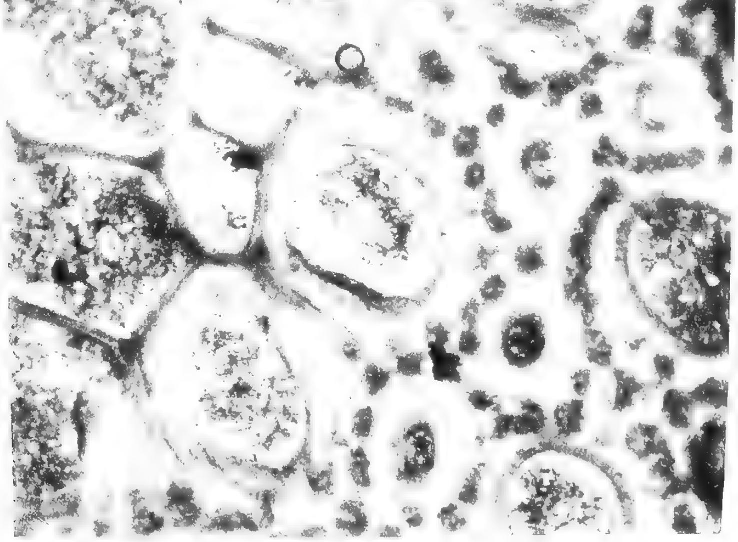

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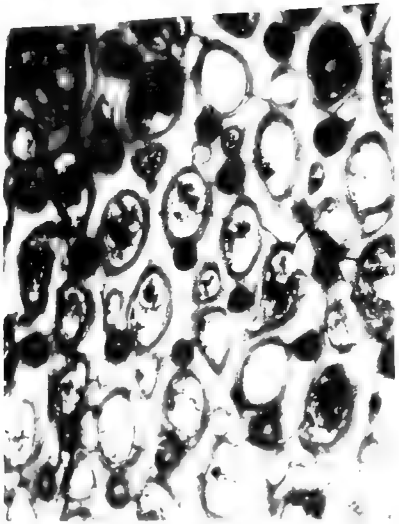
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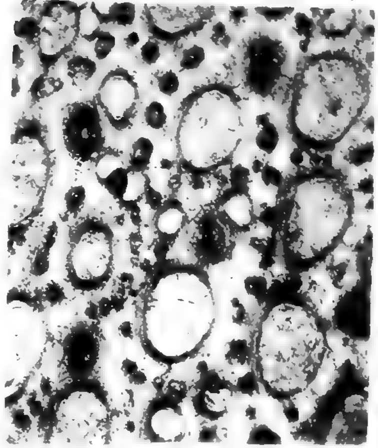
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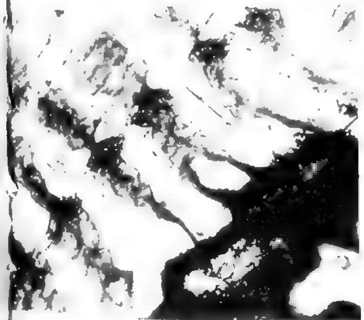
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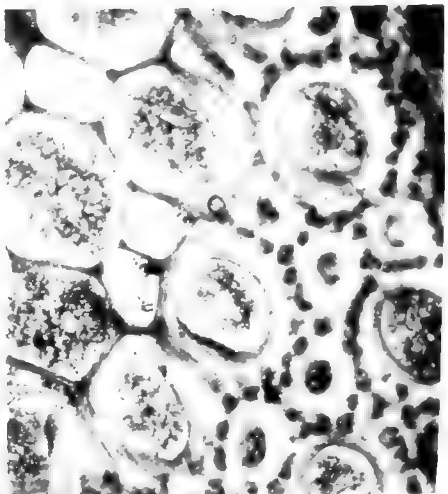
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XIV. *Note on the Autostylic Skull of Vertebrates.*

By J. Graham Kerr.

(Read 28th October 1907.)

The object of this note is to emphasise the need, for the sake of clearness, of modifying current nomenclature so as to distinguish between the two very different modes of suspension of the jaw apparatus, which are confused together under the term autostylic. Huxley, when he invented the term autostylic, used it in reference to *Ceratodus* and *Chimaera*, there being at the time no embryological data available regarding these forms.

The condition in *Chimaera* appears to be a further development of that found in *Heterodontus*, where the primitive upper jaw (palato-pterygoquadrate cartilage) is firmly adherent to the cartilaginous cranium. In *Chimaera* complete fusion has apparently taken place, the upper jaw being perfectly continuous in substance with the cranium.

In Dipnoans, on the other hand, the attachment of jaw apparatus to skull is not through the primitive upper jaw, *i.e.*, through the palatopterygoquadrate outgrowth from the mandibular arch, but through the upper part of the original mandibular arch itself. That this is so seems perfectly clear from Sewertzoff's account of the young skull of *Ceratodus*, and from Agar's reconstructions of the skull in the young *Lepidosiren* and *Protopterus*. In other words, the suspension of the lower jaw from the skull is here (as also in Amphibia) a relatively primitive one, and it should be marked off by the use of a distinct term, *e.g.*, *protostylic*, from the clearly secondary mode of suspension through the palato-pterygoquadrate outgrowth.

XV. *Note on Swim-bladder and Lungs.*
By Prof. J. GRAHAM KERR.

(Read 23rd March 1908.)

The general homology of swim-bladder and lungs is now accepted by most morphologists as being well established. There still remains, however, a good deal of divergence of opinion as to the precise way in which one has been derived from the other. I have, for some time past, been inclining towards the view that the hypothesis enunciated by Sagemehl is the correct one. According to this view, the condition in which there exists a pair of lungs with a mid-ventral glottis is the primitive one. Since Sagemehl's time this has received support from the facts of embryology of Crossopterygians and Dipnoans. According to Sagemehl, the increasing predominance of the hydrostatic function of the lungs in fish-like forms was accompanied by the gradual disappearance of one lung and the enlargement of the remaining one, which was now able to pass up to a mid-dorsal position round one side of the œsophagus. Sagemehl points to *Polypterus* as showing an early stage in this process, the left lung being here reduced and the right greatly enlarged. It is to be noted that in *Polypterus*, although the lung apparatus shows in detail a strong morphological asymmetry, yet the arrangement of the parts as a whole is practically symmetrical — the large right lung being quite symmetrical about the mesial plane except at its front end, where it bends away to the right and is balanced by the small left lung. This symmetry of the lung apparatus as a whole, in spite of the asymmetry of its constituent parts, is an expression of the important hydrostatic function of the apparatus.

A consideration of the morphological features of the lung or swim-bladder of the Dipnoans shows at once that Sagemehl's hypothesis fits in well with certain of their characteristic features. Descent of the lung-fishes from an ancestor in which the lung apparatus was in a similar condition to that in which it is in the living *Polypterus*,

would at once explain why it is that the lung apparatus of the Dipnoan invariably communicates with a ventrally placed glottis round the *right* side of the œsophagus. It also explains the at first purely ventral position of the lung rudiment in the embryo, and the undivided condition of the lung in the adult of *Ceratodus,* on the whole the most primitive existing Dipnoan. A serious obstacle, however, in the way of the acceptance of the hypothesis is found in connection with the nerve supply of the lung apparatus of the *Dipnoi.* (1) If the Sagemehl hypothesis were correct, we should expect the lung apparatus to be innervated entirely by the right vagus—as a matter of fact, it is innervated by both vagi; further (2), on this hypothesis we should expect that if a branch of the left vagus did pass to the pulmonary apparatus, it would pass to it round the ventral side of the œsophagus, whereas, as a matter of fact, the pulmonary branch of the left vagus crosses over to the right side of the lung *dorsal,* not only to the œsophagus, but also to the right vagus.

The object of this note is to show that these difficulties, insuperable as they appear at first sight, may, as a matter of fact, be justifiably disregarded. That this is so will, I think, be gathered from a study of Fig. 1, A and B showing the conditions of nerve supply to the lungs in *Polypterus,* for comparison with the lung-fishes.

Taking first objection (1), we see that in *Polypterus* the right lung, in correlation with its increase of size, invades the area of supply of the left vagus. This enlarged right lung shows a large nerve trunk running down each side, that on the right being a branch of the right vagus, that of the left a branch of the left vagus. If, therefore, the left lung were to disappear, the surviving lung, though originally a purely right lung, would show an innervation from both right and left vagi.

(2) In investigating any supposed migration of the lung apparatus, we should naturally look for a "trail" or track marked out by the course of the arteries and nerves. Examining the relation of these in the *Dipnoi,* we find the right pulmonary artery, the left pulmonary artery, and the

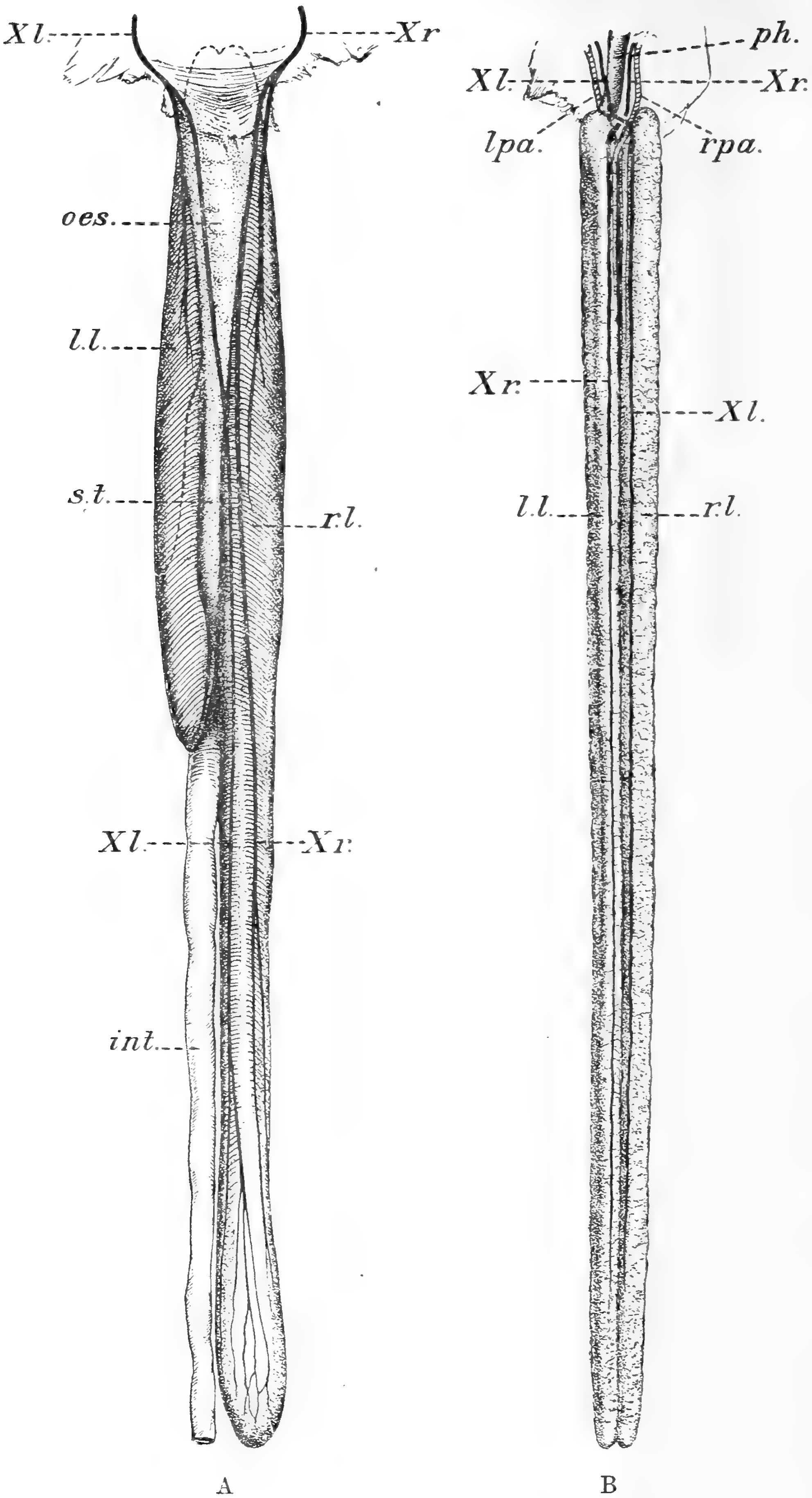

FIG. 1.—Dorsal view of Lungs of *Polypterus* (A) and *Lepidosiren* (B). (In A the right lung and intestine have been slightly displaced: the symmetrical arrangement alluded to in the text is consequently obscured.) *int.*, intestine; *l.l.*, left lung; *l.p.a.*, left pulmonary artery; *oes.*, œsophagus; *ph.*, pharynx; *r.l.*, right lung; *r.p.a.*, right pulmonary artery; *st.*, stomach; *Xl.*, left vagus; *Xr.*, right vagus.

right vagus all agree in testifying to a movement of the lung having taken place, such as would have happened on the Sagemehl hypothesis. This being so, we should perhaps be justified in disregarding the discordant evidence afforded by the left vagus, and in assuming that it is due to some secondary modification in the course of this nerve, especially as by no conceivable process of shifting of the lung rudiment can the contradiction between the evidence of the left vagus and that of the other vagus and the pulmonary arteries be removed. Whether or not it be admitted that such a course of reasoning would be admissible in the absence of other evidence, all doubt about its validity is removed by a consideration of the condition in *Polypterus.* Here it will be seen from Fig. 1 A that the nerve running along the left side of the right lung is continuous with the left vagus directly, *i.e.*, not ventral to the œsophagus, but dorsal to it. Now I think it is clear that this condition *must* be secondary. The whole lung rudiment was originally ventral in position, and it is clear that any part of the primitive rudiment coming within the area of supply of the left vagus would be connected up with the left vagus round the ventral and left sides of the pharynx. The precise manner in which the secondary connection has come about is of no importance to the general argument: it may well have been through short circuiting of nerve impulses through the nerve plexus in the mesodermal sheath of the developing pharyngeal region, the short circuit becoming eventually marked off as a thick nerve trunk.

(Such secondary anastomoses between nerve trunks are, of course, well known to occur frequently, *e.g.*, between terminal branches of paired cranial nerves in vertebrates, or in the condition of dialyneury in Gastropod Molluscs.) The point which I desire to bring out is, that in the very primitive *Polypterus* a condition holds which entirely does away with the difficulty in the way of Sagemehl's view, involved in the purely dorsal position of the pulmonary branch of the left vagus in Dipnoans. Once this difficulty has been got over, the X-like crossing of the pulmonary branches of the vagi in Dipnoans is clearly explicable by

assuming that a rotation of the lung rudiment (in a counter clock-wise direction, as seen from the tailward direction) took place as the lung became shifted dorsalwards, and before the secondary nervous connection with the left vagus became developed.

In regard to the Teleostean Fishes, it seems probable that the condition of their swim-bladder is to be looked upon as representing a further stage in the same evolutionary process as has taken place in *Ceratodus.* In them the swim-bladder has become single and dorsal, and a shortening of the pneumatic duct has led to the glottis also becoming dorsal in position. It seems unwise, in the present state of our knowledge, to look upon the departures from the mid-dorsal position of the glottis found in various Teleosts (*e.g.*, towards the right in Siluroids, towards the left in Characinids) as variations of any special phylogenetic importance. The features of the *Teleostomi* generally are such as to make it probable that they are descended from Crossopterygian-like ancestors, and that in their case also, owing to the enlargement of the right lung in these ancestors, the swim-bladder has migrated round the right side of the gut. The condition in *Erythrinus*, where the glottis is on the left side, about mid-way between dorsal and ventral sides, would still be of interest as showing the instability of the mid-dorsal position of the glottis, but would not be looked upon as representing a phyletic stage in the dorsalward migration of the glottis, as Sagemehl believed.[1]

[1] In this dorsalward migration of the glottis, probably torsion of the œsophagus about its longitudinal axis has played an important part. *Cf.* Moser, *Arch. mikr. Anat.*, 1904.

XVI. *Notes upon a Haplosporidian belonging to the genus Icthyosporidium.* By MURIEL ROBERTSON, Carnegie Research Scholar in the University of Glasgow. [Plates IX. and X.]

(Read 16th December 1907.)

In December 1905 MM. Caullery and Mesnil embodied in an interesting memoir[1] all the knowledge on the Haplosporidia so far forthcoming. They divided the order into three families—(1) *Haplosporiidæ,* (2) *Bertramiidæ,* (3) *Coelosporiidæ,* and a fourth group containing forms of doubtful affinities. It is to the second of these families, namely, the Bertramiidæ, that the parasite I wish to discuss belongs.

Caullery and Mesnil created the genus *Icthyosporidium* for two tissue parasites, *Icthyosporidium gasterophilum* and *Icthyosporidium phymogenes,* which they found in certain fishes, and placed the genus provisionally in the family of the Bertramiidæ. There is, as far as I can see, no reason for removing the genus from this family. The present parasite belongs undoubtedly to the genus *Icthyosporidium,* but although closely allied to *Icthyosporidium gasterophilum,* it does not completely agree with either of Caullery and Mesnil's two species. The differences between this parasite and *Icthyosporidium gasterophilum* will be summarised later on in this paper.

One hesitates to create a new species, more especially when dealing with incompletely known forms. I therefore propose to place the parasite in the genus *Icthyosporidium,* while leaving the species name on one side. Future investigation of this little known group will settle the question of separate species much more satisfactorily than can be done in the present state of our knowledge.

The parasite was found in large quantities in the liver and in the wall of the alimentary canal, and also in the mesentery of a small flounder in January 1906. The flounder

[1] *Arch. Zool. Exp.,* T. iv. No. 3.

had been living some months in the tanks of the Millport Marine Station, and was harbouring two species of nematode, a large number of a species of trematode, and a trypanosome as well as *Icthyosporidium.*

The alimentary tract showed a very marked reaction to the presence of the *Icthyosporidium.* The liver was of a dull ochre colour, with numerous small hard lumps. The part of the liver where these lumps were most numerous was bright green. The intestine showed thickenings of the wall in places, and several cæcal outgrowths of about ½ to 1 cm. in length. The spleen was considerably enlarged, but otherwise normal.

The condition of the alimentary tract, and also the appearance of the parasite in the live state, suggested at first that I was dealing with *Lymphocystis johnstonei,* described by Woodcock.[1] Further investigation, however, showed that the form in question differed in the most essential feature from that described by Woodcock. Thus *Lymphocystis* is said to possess a single ill-defined nucleus, whereas *Icthyosporidium* is certainly, in all the stages which I have observed, a multi-nuclear organism with small but very definite nuclei of a quite characteristic protozoon type.

The parasite did not lend itself to investigation in the live state, so parts of the liver were fixed in corrosive sublimate solution and in Flemming's fluid, and cut into thin serial sections. A variety of stains were used:—Heidenhain's iron hæmatoxylin, Ehrlich's hæmatoxylin, thionin, and eosine saturated solution in 70 per cent. alcohol, followed by 1 per cent. aqueous methylene blue. The best of these was Ehrlich's hæmatoxylin, and next to it the eosine and methylene blue. Thionin stained the protoplasm too deeply, and Heidenhain seemed very difficult to control, and rather untrustworthy.

The intestine was also cut into thin sections, and gave some interesting results, though the material was not histologically in so good a condition, as it had been fixed for the most part in picroformol, and not quite sufficiently carefully treated in the washing out.

[1] *Trans. Liverpool Biol. Soc.,* vol. xviii., Session 1903-1904, p. 143.

In the most conspicuous and obvious stage the animal is spherical, with a very well marked outer membrane or envelope. This envelope varies in thickness, and appears to me to be secreted by the parasite. It is smooth, and apparently almost structureless, occasional slight circumferential striations indicating that it may very possibly develop in concentric rings. The envelope or cyst-wall appears to be of rather a stiff gelatinous consistency, and stains faintly with Ehrlich's hæmatoxylin, also with eosine, but remains, as a rule, quite unstained by Heidenhain's iron hæmatoxylin method. The outermost limit of the envelope is occasionally somewhat crinkled.

The word cyst, as used in Protozoan literature, has such a wide and indefinite connotation that I think it is expedient to define exactly the sense in which it is used here. The cyst-wall is, in the present case, a gelatinous envelope secreted by the parasite while in the trophic state; growth may take place, and all the ordinary metabolic processes appear to go on without interruption. The parasite leaves the cyst in the trophic condition, and may apparently again secrete a similar envelope. The breaking up into reproductive bodies occurs, as will be seen later, after the animal leaves the cyst. In the protozoon under discussion the cyst-wall is simply the envelope of the trophozoite, and is in a sense comparable to the shell secreted by, for instance, an *Arcella*. The parasite is immobile while in the cyst, but seems capable of a certain amount of movement upon leaving it. Surrounding the cyst is a nodule or capsule of connective tissue. The presence of the parasite causes a proliferation of the connective tissue of the host, which forms a usually circular nodule, sometimes of very considerable size. In this paper the term nodule applies to the connective tissue masses, and the word cyst to the envelope of the circular parasite.

The thickness of the cyst-wall bears no very constant relation to the size of the *Icthyosporidium*, but may, as will be seen later on, have a relation to the length of time spent by the parasite in the one position. As regards size, the creature varies between very wide limits; one of the

larger spherical forms may have a diameter of 100 μ or even more. The protoplasm varies slightly in character. It is in many individuals very finely and evenly granular throughout its whole extent, showing no differentiation into ectoplasm and endoplasm, and is quite free from vacuoles or other inclusions (Fig. 2). In other cases it may be more or less vacuolated towards the centre, or may show a slightly coarser granulation; occasionally refractive inclusions may be present which stain with eosine and also with thionin. These last are, however, not very frequently met with. Sometimes there may be a ring of protoplasm towards the centre which takes the stain a little more deeply than the rest of the protoplasmic body, and occasionally the nuclei are grouped to a certain extent within the ring. I do not think that this appearance has any particular significance.

The numerous nuclei are of a type which is widespread amongst the Protozoa, but more usually found in flagellates than in other forms. It is characterised by the presence of a relatively large central karyosome—the "Binnenkörper" of Senn—surrounded by a fine sharply marked membrane, which takes up the chromatic stains to a certain extent; the intervening space between the karyosome and the membrane being traversed by fine staining threads which radiate out from the karyosome. This nucleus might be represented as a bubble containing a small sphere, with radial strands passing from the sphere to the wall of the bubble (Figs. 2, 3, etc.). That the nucleus is spherical and not wheel-shaped, as, for instance, that of some trypanosomes, is quite obvious from the fact that the same appearance is always presented, no matter from what aspect the nucleus is observed. The karyosome of the nuclei in *Icthyosporidium* is in the resting-stage very homogeneous and compact in its appearance, and, except for the small size, is identical with that of many free-living flagellates. The fine rays just described have not been observed in *Icthyosporidium gasterophilum* nor in other members of the order of the Haplosporidia, although nuclei identical in all other respects are not uncommon in the group. These rays are, however, absolutely constant

features, although some stains bring them out more clearly than others. The hæmatoxylin in Heidenhain preparations is usually washed out during the differentiation; and the delicate rays are thus often rendered invisible. Ehrlich's hæmatoxylin stains them very clearly. I feel that these structures are of some importance in this parasite, as they dispose of the possibilities of what I have called the nuclear membrane being at this stage really the spore membrane—a not unreasonable hypothesis, in view of the condition found in *Coelosporidium chydoricola*.[1]

The nuclei are relatively very small, but the size is subject to some variation, though there does not seem to be any very definite correlation with that of the whole creature. There does, however, seem to me to be a relation between the distribution of the nuclei and their size. The nuclei may be arranged very evenly through the protoplasm, which in these individuals is pretty generally, though not invariably, of the homogeneous uninterrupted type (Fig. 2). In these individuals the nuclei are usually large in size, although the bulk of the whole parasite may vary. The large parasites are, nevertheless, very often of the type just described. Where the nuclei are arranged more closely together in a core which runs through the parasite, they are often smaller, and the protoplasm may show vacuolation towards the centre (Fig. 3). Sometimes the nuclei are arranged in concentric rings. It is doubtful whether there is much significance in the question of the distribution of the nuclei, or even in the variation in size. This last might possibly depend on the relative length of time from the last mitosis, or upon the relation of the number of nuclei to the mass of protoplasm.

I cannot, from any of the appearances presented by this parasite, find that there is reason to suppose that the increase in size of the space within the nuclear membrane indicates that the structure is being differentiated into a spore whose outer membrane corresponds with the nuclear membrane. Caullery and Mesnil seem to have found this

[1] *Arch. Zool. Exp.*, T. iv., No. 3, p. 142.

method of spore development in *Haplosporidium scolopli*.[1] A similar development seems to be implied in the description of the sporozoites of *Coelosporidium chydoricola*,[2] and suggested in the case of *Icthyosporidium gasterophilum*. There is no inherent impossibility in this method of development, and the case of *Haplosporidium scolopli* seems to be well founded. Nevertheless I do not see any evidence in the parasite at present in question to indicate that it occurs here; the mere increase in size is by itself not a point of any weight in this direction. Evidence against it is, I think, afforded in this particular instance in the persistence of the fine rays between the karyosome and the membrane.

Division of the nuclei may occasionally be seen, and it may be noted that it occurs simultaneously throughout the whole animal. It is difficult to obtain very precise information as to the finer details of the nuclear division, partly owing to the extreme smallness of the nucleus and partly to the fact that although an immense number of parasites have been reviewed, stages with dividing nuclei have only occasionally been met with in the material at my disposal. In the case of the Protozoa, where a happy diversity of method is found in the process of nuclear division, it is unwise to form conclusions without a large number of observations to draw from. It may therefore suffice to state here that the nucleus appears to divide by a modified form of mitosis, without, as far as I can see, the formation of an equatorial plate. Figs. 4 and 5 illustrate the process.

The smallest forms hitherto met with show two nuclei. They are spherical or subspherical bodies—with the appearance of being composed of soft protoplasm. They have no well-marked envelope, and seem only to be bounded by a thin membrane. The nuclei are identical with those described above. These small parasites are usually found lying together in groups. They sometimes give the appearance of being inside a tissue cell, but certainly lie between the cells when they are a little larger (Fig. 6).

The development of such a small creature into the larger

[1] *Arch. Zool. Exp.*, T. iv., No. 3, p. 113.

[2] *Ibid.*, T. iv., No. 3, p. 142.

parasite already noted appears to be as follows:—The animal increases in size, the nuclei dividing simultaneously by an apparently very simple method of mitosis. Round the parasite there begins to be formed a nodule of connective tissue, which shows the typical concentric layer appearance so often found in cases where a parasite is invading the tissue of a vertebrate host. As far as the nodule of connective tissue is concerned, some of these earlier stages exactly recall the similar concentric nests formed round certain tissue-inhabiting nematodes. The parasite and the nodule both increase in size, and the former gradually secretes the gelatinous cyst-wall already mentioned.

After a time the *Icthyosporidium* begins to quit its cyst (Figs. 3 and 7). It is rather difficult to determine precisely what conditions the exit of the parasite. It is very probable that the increase in size overcomes the tenacity of the envelope. Occasionally oval or oblong cysts are met with, apparently indicating that the increase in size of the parasite has stretched the capsule unequally. The actual size of the animal seems to have nothing to do with its quitting the cyst. Parasites of very varying sizes may be found in the act of creeping out, if a sufficiently large amount of material is carefully searched. The most usual method of exit is for the animal to push out one part of the cyst-wall in a more or less broad process,—sometimes this outpushing may be shaped like a finger, or may form quite a wide bay. The outermost layer of the cyst-wall bursts first, but the inner parts seem to be more elastic, and still ensheath the protoplasmic body. The whole parasite may become very elongated, though without any very marked increase in size taking place. The inner part of the cyst may now rupture also, and the naked parasite appears to slip out among the tissue of the nodule. Completely empty cysts are quite often met with, some of them showing precisely the same shape as that in Fig. 7, which here still encloses the parasite. Sometimes the inner part of the cyst-wall stretches to a much greater extent than shown in this figure, but there seems to be a great deal of variation. While this is one quite typical

method of exit, modifications, due probably to the relative sizes of the animals, the rapidity of growth, and the elasticity of the cyst-wall, occur very frequently. Thus Fig. 3 shows the early stage in the case of a rather more massive animal. Here the cyst has burst at once throughout the whole thickness of its wall, and the parasite is simply growing out into the surrounding tissue. The empty cyst here will be a hollow sphere broken at the place of emergence of the parasite. These empty cysts very usually become filled up with intrusive connective-tissue cells. This process of filling up is a common occurrence, and all the different stages can easily be traced in well-infected tissue. Sometimes the intruding cells, in the case of a nodule of long standing, may be separate cells, and may keep their separate condition for some time. At first sight these were rather bewildering appearances, suggesting some extraordinary form of spore-formation. A little study, however, soon betrayed their true origin, and they proved in every case to be quite unmistakably intrusive connective tissue. Fig. 8 illustrates this point.

Two courses seem to be followed by the issuing parasite. It may break up almost at once into a number of small bodies usually containing two nuclei; this process is shown in Figs. 9 and 10. These are drawings of two consecutive sections, and depict an animal which has broken up immediately upon issuing from the cyst. These little bodies become distributed over quite a small area, usually inside the original connective-tissue nodule, and appear to start growing pretty soon. Sometimes they seem to become intracellular, but I cannot be sure upon this point. The connective tissue in the nodule proliferates, and the little parasites thus become separated from each other, often each of them as their size increases becoming the centre of a nest of connective-tissue cells. Large subsidiary nodules may be formed which project out from the edge of the original one—a circumstance which accounts for the multiple character of the tumours, as seen from an external examination of the liver before sectioning. The

older nodules may sometimes assume very large proportions several millimetres in diameter, and encroach very seriously upon the tissue of the liver. The number of parasites in such a nodule is difficult to estimate, but must embrace many hundreds. It is to be noted that the young parasites are very usually found lying together in groups, sometimes comprising very large numbers.

Fig. 11 represents a parasite which has broken up immediately upon issuing from the capsule,—multiplication of the nuclei and growth seem already to have begun.

The other path taken by the parasite upon issuing from the cyst is as follows:—The parasite as soon as it has burst the cyst begins to grow (Fig. 13) actively, and increases enormously in size,—it may become as much as a millimetre or more in length. It coils itself in the shape of an irregular worm through the nodule, and may even go outside it into the tissue of the liver, though this is not very often seen. It may branch, and may also apparently break up by plasmotomy into irregular masses of various sizes. Sometimes parts of this complex mass of protoplasm secrete an envelope, but it is not often continuous over the whole creature, especially not in the case of the larger individuals. The form of animal in this stage seems strongly to suggest that it might be capable of amœboid movement, but this is merely a deduction from its appearance, as I have never seen this form alive. The ultimate fate of this creature is obscure. It appears to me, from the material studied, that the masses derived from it by fission round themselves off, secrete an envelope, and proceed with their growth. This would account for the varying relation between the size of the parasite and the thickness of the cyst-wall. It may possibly be that some of these large irregular individuals break up ultimately into small reproductive bodies, as described above. One is led to suspect this from the fact that sometimes many hundreds of small individuals may be seen lying in close apposition to each other, suggesting that they have arisen from the breaking up of a very large individual, or from the simultaneous breaking up of several smaller creatures.

There is, however, too little data to admit of any certainty upon these points. The method of growing out, and the apparent capacity for movement of these large creatures, seem to indicate that they serve to distribute the parasite over a wider area of the host tissue. Fig. 12 is a drawing of a section through part of one of these individuals. The parasite here is very large and irregular in shape. At one point (P) what appears to be a stage in the process of plasmotomy may be seen. Empty portions of the envelope are seen, secreted by parts of the parasite during its passage through the connective-tissue nodule. The parasite here was very large, and stretched through quite a number of sections. It is drawn under a lower power than the other figures, *i.e.*, three-fourths of their size.

The parasite as found in the intestine shows all the characters described above. It lies in the thin layer of connective tissue that runs up the villi and between the muscular sheath of the intestine and the epithelium lining it. *Icthyosporidium* is essentially a tissue parasite, and causes great nodules to be formed in the spaces between the epithelium of the villi, giving the intestine a most remarkable appearance when seen in section. The whole wall of the intestine may grow out to form a cæcum of some size, ·5 to 1 cm. in length. The nodules of connective tissue, both here and in the liver, are at first very definite, with well-marked concentric layers of cells. Later, as the parasites increase in number, the nodule enlarges very much, and the cells composing it show a tendency to become separated from each other, and may show hypertrophy of the nuclei. There appears to be a tendency for each parasite within the nodule to act as the focus of a nest of connective-tissue cells. This of course separates the parasites from one another, and greatly increases the extent of the area of reacting host tissue. In late stages this tendency becomes less marked in the centre of the nodule, which becomes rather broken up, but seems always to occur at the edges of the invading mass of connective tissue. I have never seen the *Icthyosporidium* here described in the epithelium of the intestine, but the growing nodules seem occasionally

to break through the epithelium, and the parasites appear to become free in the intestine.

General Considerations.

As far as I have been able to observe, there is no sign of a sexual reproductive process in the parasite here discussed. I have no reason to assume that the nuclei of the apparently binucleate reproductive bodies fuse together at any part of their development, nor have I found any fusion of nuclei previous to the formation of these bodies. The word spore is used with much looseness in the case of the more obscure Sporozoa, such as for instance the group at present under discussion.

Schaudinn's now familiar terminology might, I think, be applied with advantage to forms like *Icthyosporidium*. Arnold Lang in his "Protozoa" (*Lehrbuch der vergleichende Anatomie*), speaking of "spore-formation"—"Fortpflanzung durch Zerfalltheilung"—says with much justness, "Diese Fortpflanzungsweise ist bis zetzt fast allgemein schlechthin als Sporenbildung bezeichnet werden. Allein das charakteristische der Zerfalltheilung ist nicht die Bildung von Sporen sondern die art wie die Sporen gebildet werden." According to Schaudinn's nomenclature, these reproductive bodies may be called merozoites, as they are formed by the simultaneous breaking up of the trophozoite, and are not preceded by any sexual process. Their binucleate character is, I think, no disability, neither is the "spore-capsule" found in other members of the Haplosporidia in my opinion any reason for rejecting the terms until a sexual process is observed. To put this last point more precisely, the animal which emerges from such a spore is not a sporozoite but really a merozoite.

This term does not, of course, apply to the Myxosporidia, as the reproductive bodies are formed while the parent individual is still in the trophic state.

I am quite ignorant as to how the infection is spread from one host to another.

In conclusion, I wish briefly to summarise the points of difference and resemblance between *Icthyosporidium gasterophilum* as described by Caullery and Mesnil,[1] and the *Icthyosporidium* here described.

In *Icthyosporidium gasterophilum* an external envelope or cyst-wall is only exceptionally present. The nuclei show no rays between the karyosome and the nuclear membrane.

Plasmotomy occurs.

The parasite is restricted to the glands of the stomach and the pyloric cæca of various shore fishes, chiefly *Motella mustela* and *Liparis vulgaris.*

In the *Icthyosporidium* described in the present paper, a well-developed cyst-wall is very generally present. The nuclei show fine rays between the karyosome and the nuclear membrane.

Plasmotomy occurs.

The animal comes out of its cyst and breaks up into reproductive bodies, which appear to be binucleate.

The animal causes much disturbance of the tissues of the host *Pleuronectes flessus* and proliferation of the connective tissue. It is found in the liver, the wall of the gut, including the stomach, and in the mesentery.

The work recorded in this paper was carried out in the Zoological Laboratory of the University of Glasgow under the direction of Prof. J. Graham Kerr.

Explanation of Figures.

The figures, with the exception of Nos. 6 and 12, were drawn under the 3 mm. Homog. Imm. Apochromat by Zeiss with an 8 compensating ocular with the aid of the camera lucida.

Figure 6 was drawn under a $\frac{1}{12}$ oil immers. by Reichert with a compensating ocular No. 8 (Zeiss).

Figure 12 was drawn under the 3 mm. Homog. Imm. Apochromat by Zeiss with compensating ocular No. 6. All the figures were reduced to $\frac{2}{3}$ of their size in reproduction.

[1] *Loc. cit.*

Fig. 1 shows a medium sized *Icthyosporidium* enclosed in a nest of connective tissue, the protoplasm is vacuolated towards the centre. Through an error in drawing, the nuclei have been made too small.

Fig. 2. *Icthyosporidium* with homogeneous protoplasm, and large evenly distributed nuclei.

Fig. 3. Parasite issuing from its cyst. The nuclei are arranged towards the centre of the animal. The protoplasm shows vacuoles.

Figs. 4 and 5. Division of the nuclei.

Fig. 6. Group of young individuals.

Fig. 7. Exit of parasite from its cyst.

Fig. 8. Abandoned cyst filled with connective tissue.

Figs. 9 and 10 illustrate the breaking up of an individual into reproductive bodies.

Fig. 11 shows the results of this breaking up process. The young individuals have already begun to grow.

Fig. 12. Section through a nodule with one of the large worm-like individuals. It has been cut in several places, thus giving the appearance of several separate creatures.

At P a stage in the process of plasmotomy may be seen.

Fig. 13. Early stage in the exit of one of these large forms from the cyst.

[The above notes were handed to me by Miss Robertson previous to her departure for Ceylon in the summer of 1907, and therefore do not contain references to more recent literature.—J. Graham Kerr.]

XVII. *Note on a Large Antipatharian from the Færoes.* By Prof. J. Arthur Thomson, M.A. [Plate XI.]

(Read 24th February 1908.)

In the summer of 1907 I obtained from Mr George Sim, Aberdeen, a remarkable specimen which had been brought in by a trawler "from the north-east of the Færoe Islands." It was remarkable in being an Antipatharian, for the occurrence of a representative of this order in northern waters near Britain was, to say the least, unexpected. It was remarkable in the second place, because of its huge size, for it stood over a yard in height. I wish to take this opportunity of thanking Mr Sim for his kindness in allowing me to have this interesting specimen for the University Museum. This is indeed but a minor instance of the disinterested way in which the indefatigable and learned author of *The Vertebrate Fauna of Dee* has placed valuable material, as well as knowledge, at the service of scientific workers in many departments of Zoology. A word of appreciation may also be permitted in reference to the sagacity of the fisherman who recognised that the Antipatharian was "something new," and took the trouble to bring the large specimen home.

The specimen stands 3 ft. $2\frac{1}{2}$ ins. high, and consists of a substantial main stem with more than half a dozen strong branches. It is attached by a broad base ($1\frac{1}{2}$ ins. $\times$ $1\frac{7}{8}$ ins.) to a stone which measures $9 \times 7 \times 3\frac{1}{2}$ ins. and weighs several pounds, so that all thought of the specimen having been washed from elsewhere is out of the question. The main stem has for the greater part of its length a diameter of about 8 mm., and its section shows the well-known characteristics of "black coral." Five branches which remain fairly complete attain a very considerable length, the longest being almost as long as the main stem (2 ft. 8 ins.). It should be noted that the intact specimen must have been much more than a yard in height, for the main stem is broken off while still showing a diameter of about 7 mm.

There have been at least eight fairly strong primary branches, arising irregularly and at various angles from the main stem, and one of these which was broken off, and was heavily weighted with large clusters of barnacles (*Scalpellum vulgare*), had an irregularly elliptical section, about 8 mm. by 6 mm. From the strong primary branches a few secondary branches arise, and all the branches bear very numerous twigs or pinnules, with which the main stem was also beset, as the more or less broken stumps plainly show. The twigs or pinnules arise on all sides of the primary and secondary branches in somewhat irregular vertical rows. They arise for the most part at right angles, and in some parts there are rather vague indications of six vertical rows. As many as forty-eight pinnules may occur on a centimetre, and thus a dense bottle-brush appearance results. The twigs or pinnules have a thread-like axis (0·18 mm. in diameter), and stand out stiffly, but they are as flexible as a fencing-foil.

Only a few spines were seen on the branches, but they occur in typical abundance on the delicate twigs. Three rows are fully visible on one aspect, and there are actually six vertical rows. These spines are minute, fairly sharp triangles, curved slightly upwards and not closely appressed. In many cases they project for 0·09 mm., but they are not all of the same size. Those observed on the branches are larger but lower than those on the pinnules, and even on the same pinnule there is some inequality. The distance between two adjacent spines on a vertical row varies from 0·5 to 0·75 mm., and is by no means regular.

The reason for these details will be obvious when I mention the unfortunate fact that not a word can be said in regard to the polyps of this interesting specimen. When it came into my hands, it showed abundant remains of the cœnenchyma, but no definite trace of any of the polyps could be found. Two or three of the best pieces were immediately fixed, but they only showed that the polyps were hopelessly decomposed. This is peculiarly unfortunate, because it is very difficult to identify an Antipatharian apart from its polyps.

In the absence of any polyps, I could not do more than give close attention to the mode of branching, the arrangement of the twigs, and the disposition and character of the spines. By comparing the Færoe specimens with others, and by following a method of exclusion, I have convinced myself that it is referable to the well-known Mediterranean species—*Parantipathes larix* (Esper), see Brook (1889, p. 142). If this conclusion is correct, the occurrence of this species to "the north-east of the Færoe Islands" is of great interest, which is increased by Professor Hickson's record (1907) that *Parantipathes larix* was collected by the "Huxley" from the north side of the Bay of Biscay in August 1906.

Recognising the scientific responsibility of stating that a well-known Mediterranean species occurs in such high latitudes as north-east of the Færoes, I have carefully considered all the Antipatharians in Brook's "Challenger" Report and in subsequent publications, and I find that, apart from *Parantipathes larix,* there is only one other Antipatharian which the Færoe specimen resembles in any marked degree, and that is *Taxipathes recta,* Brook (1889, p. 156), which is only known by a single specimen, obtained off Ascension. That this species cannot include the Færoe specimen might perhaps be inferred from the distribution, but as that is a dangerous way of arguing, I may point out that, while *Taxipathes recta* resembles *Parantipathes larix* and our specimen in certain respects, *e.g.*, in having the same kind of delicate simple pinnules arranged in a brush in six vertical rows, it may be left out of consideration because of its extremely stiff rectangular branching, its rigid and absolutely regular pinnules (only 18 to 21 to a centimetre, moreover), and its spinulation (with four vertical rows of spines on one aspect). It need hardly be said that the presence of even a few polyps would have obviated even a minute's consideration of whether the form in question was referable to the Schizopathinæ, among which *Taxipathes* is included, or to the Antipathinæ, among which *Parantipathes* is included.

The real difficulty in regard to the specimen from the

Færoes is that it cannot be regarded as a typical representative of the species to which it seems most reasonably referable, namely *Parantipathes larix.* It differs from the type in having several branches from the main stem, in not having the pinnules of a row strictly in one plane, in having more numerous pinnules (over 20 in three cm. of one vertical row, instead of about 11), and in having flexible, not "rigid," pinnules. But in Brook's detailed description it is stated that the pinnules of a row are "almost in one plane," and we may also note that the pinnules of a fine specimen of *Parantipathes larix* from Naples, are anything but rigid in the sense that an icicle is rigid. They are flexible like a foil.

Our specimen agrees with *Parantipathes larix* in having the pinnules in six vertical rows (though these are decidedly irregular), in having six pinnules to one revolution of the axis, in showing three longitudinal rows of spines on one aspect of a pinnule, and in having similar spines not uniform in size. We have compared a pinnule of a Naples specimen with a pinnule from the Færoes specimen, and we find them practically identical. Therefore we conclude that the Færoes specimen is referable to *P. larix,* although it deviates from the type in certain respects, such as branching. The deviations may be growth-reactions to a very different environment.

We make no apology for entering into details on this subject of specific identification, for in all such questions one is only too apt to err in the opposite extreme. At first sight it seemed impossible to identify the weathered specimen from the Færoes with a perfectly preserved specimen from Naples, yet we think that this is necessary. This means that Brook's description of the species as (*a*) with stem "simple or rarely branched near apex," (*b*) with pinnules in six planes, and (*c*) with pinnules rigid, about 11 in each vertical row for 3 cm., requires to be modified in regard to each of these points. When we think of plants, *e.g.*, forms like "Shepherd's Purse" and "Whitlow Grass," to which the ramose colonial Cœlentera are in so many ways comparable, or when we think of

many of the hydroids, we can well understand that divergences in regard to growth-characters are to be expected between representatives of the same species of Antipatharian, living in growth-conditions so diverse as those afforded by the relatively sheltered Mediterranean and the stormy seas to the north-east of the Færoes.

In discussing North Atlantic Antipatharians, Brook noted that "*Antipathes* (?) *arctica,* Lütken, is apparently the only species which has been obtained north of latitude 47° N.; it has been obtained on two occasions off the coast of Greenland. The occurrence of *Cirripathes spiralis* (Linn.) off the coast of Norway appears to me very doubtful, and requires confirmation before the species can be admitted into the above list" (Challenger Report, xxxii., 1889, p. 182).

On this statement three notes may be made :—

(1) Lütken's remarkable species, *Antipathes arctica,* from North Greenland, bears no resemblance to the specimen from the Færoes.

(2) The Færoes lie between 61° and 62° N., which is far to the north of the 47° which Brook mentioned as the highest latitude known for any North Atlantic Antipatharian except Lütken's species.

In 1905 Prof. Hickson recorded the occurrence of three Antipatharians from the West Coast of Ireland (about 53° and 54° N.), but these forms have not been reported on as yet.

(3) The three Antipatharians recorded by Prof. Hickson from the north of the Bay of Biscay, namely—*Stichopathes spiralis,* Pourtalès, *Parantipathes larix,* Esper, and *Schizopathes crassa,* Brook, were not obtained from higher latitude than 48° 7′ N. Six specimens of *P. larix* were obtained from latitude 48° 7′ N., longitude 8° 13′ W., 412 fathoms. They varied in length from 225 mm. to 325 mm., and were therefore small in comparison to the Færoes specimen.

Of other definite records of *Parantipathes larix* I have not been able to find more than the following:—(*a*) in 1896 Prof. L. Roule dredged this species in the Bay of

Biscay from a great depth (1220 metres); (*b*) His Serene Highness the Prince of Monaco collected this species (1886-1902) from four stations, of which the farthest north was 43° 57′, while the nearest the equator was 15° 17′ N. The inference seems to be that the distribution of *Parantipathes larix* is remarkably widespread. It is interesting to notice that in three of the four specimens dredged by the Prince of Monaco the polyps were absent, as in our specimen.

Summary.

A large Antipatharian, over a yard in height, consisting of a strong main stem with several long branches, was trawled to the north-east of the Færoe Islands. Numerous filiform pinnules, arranged in six irregular rows, give the branches a bottle-brush appearance. The pinnules bear six vertical rows of minute triangular spines. For these reasons the specimen is referred to *Parantipathes larix* (Esper), and the reference involves a slight modification of the diagnosis of the species, as well as a great extension of its previously recorded range of distribution.

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EXPLANATION OF PLATE.

The large figure represents the complete colony of *Parantipathes larix* ; the inset a portion of a branch showing pinnules.

XVIII. *Some further Records of Collembola and Thysanura from the Forth Area.* By William Evans, F.R.S.E.

(Read 23rd March 1908.)

The main object of these notes is to put on record a number of fresh localities within this area for some of the less common Collembola or Spring-tails included in the paper on the group by Professor G. H. Carpenter and myself, published in 1899 in the *Proceedings* of this Society.[1] Most of these localities, it will be found, carry the distribution of the species to which they refer into fresh counties, and all the records, I may say, are based on my own observations. Including *Isotoma minuta*, Tullb., and the *Tetracanthella*, which are interesting additions to our list, there are now 63 species of Collembola known from the Forth area.

Collembola.

Sminthurus hortensis, Fitch.—Otterston, Fife, July 1901, a few specimens taken on footpath. My previous localities for this species in "Forth" were all in the Lothians.

S. luteus, Lubb.—Further localities for this species are Blair Adam, near Kinross, June, and Castle Campbell, near Dollar, July 1901.

S. violaceus, Reut.—On footpath, public road, at Otterston, Fife, July 1901, six specimens secured. *Isotoma palustris*, var. *maculata*, also occurred on this footpath.

S. malmgrenii, Tullb., var. *elegantulus*, Reut.—In Oct. 1902 this pretty little form was met with in some numbers on peat pools near the top of Lammer Law, Lammermuir Hills. In Feb. 1900, Dr Folsom, of Cambridge, U.S.A., wrote me that his *S. socialis* is identical with this form, specimens of which I had sent him for comparison.

[1] Vol. XIV. pp. 221-266, 4 pls. *Cf.* also our further paper, XV. pp. 215-220, 1 pl., and my Perthshire list, *Trans. Perth S. N. Sc.*, iii. p. 150.

S. aquaticus, Bourl.—Burntisland Reservoir, June 1906; Upper Elf Loch, Nov. 1901, etc., common;[1] Duddingston Loch, July 1905; pond near Roslin, June 1906. The reddish-violet variety, var. *levanderi*, Reut., was sent to me by Mr R. Godfrey from Loch Awe in June 1900, but I have not yet met with it in this district.

Papirius cursor, Lubb.—As no Fife locality for this is given in previous papers, I may mention that it has since been found by me near Culross and Aberdour.

Tomocerus plumbeus (L.).—Glencorse Woods, several, March 1901.

Cyphoderus albinus, Nic.—A second locality for this interesting species is Abbey Craig, near Stirling, where I found it plentifully in April 1905. As usual, it was in nests of the small yellow ant, *Lasius flavus*. [Also in nest of same ant at Gullane Ness, May 1908.]

Seira (*Pseudosinella*) *cavernarum*, Mon.—Common in burrows of bees (*Andrena*) and in worm-holes, banks of the Tyne at Ormiston, June 1900; Bonnytoun Hills, Linlithgow, a few under stone well embedded in the soil, Aug. 1901. Identification confirmed by Professor Carpenter.

Entomobrya albocincta (Templ.).—Taken commonly under bark at Raith (Fife), June, and near Bo'ness (Linlithgow), Aug. 1901. *E. nivalis* (L.) has also been noted at Raith, etc., in Fife, and at Bonnytoun and Drumshoreland in Linlithgowshire.

E. marginata (Tullb.).—A specimen which I refer to this form was taken on the Isle of May in Sept. 1905.

Orchesella villosa (Geoff.).—In April 1901, and again in 1906, this fine species was found in plenty under sticks and stones in the woods about Kincardine-on-Forth, Culross, and East Grange. I have not yet met with it farther east, nor on the south side of the Forth.

Isotoma maritima, Tullb.—A good many among cast-up seaweed on the shore at Culross, April 1901.

I. grisescens, Schäff.—Near Bo'ness, Aug. 1901, and Thornton Woods (Fife), Dec. 1905, several specimens.

[1] Evans, *Ann. Scot. Nat. Hist.*, 1905, p. 216.

I. arborea, L. (=*sensibilis*, Tullb.).—Examples with the typical three-toothed mucro were abundant among sphagnum and other moss near Thornton (Fife) in Dec. 1905.

Isotoma minuta, Tullb.—During the winter of 1905-1906 the people of Edinburgh were much alarmed by the presence of small insects, erroneously referred to as "Water-fleas," in many of the hydrants and cisterns in the city. Specimens were sent by the Sanitary Inspector to Dr R. H. Traquair, who at once recognised them as Collembola, and referred them to me for specific determination.[1] The commonest form by far, both in the cisterns and in the hydrant boxes, was the white and blind *Isotoma fimetaria* (L.), Tullb. In one phial, however, there were about a score of a smaller, purplish species (scarcely 1 mm. in length), agreeing in all essential points with the descriptions of *Isotoma minuta*, Tullb. They were taken from the surface of the water in a cistern in Bruntsfield Avenue, Edinburgh, on 20th Dec. 1905. The foot and mucro (× about 500) are here shown. The species does not appear to have been previously detected in the British Isles. From one of the hydrants a few examples of *Templetonia nitida* (Templ.) were obtained.

Tullberg[2] found *Isotoma minuta* in great abundance in a sawdust heap in Gotland, Sweden. Schäffer[3] says, "Von dieser Art habe ich in Februar 1896 viele Exemplare im Keimkasten der Samenkontrollstation in Hamburg beobachtet." Axelson,[4] writing in 1900, says, "Diese vorher nicht in Finland gefundene Art, scheint ziemlich allgemein unter Blumentöpfen in wohnzimmern and Treibhäusern vorzukommen."

Anurophorus laricis, Nic.—Carribber, Linlithgowshire, March, 1902; Cullalo, Fife, Feb. 1903; Isle of May, April 1908.

[1] *Cf.* Sanitary Inspector's Report, March 1906.

[2] "Sveriges Podurider," 1872, p. 48.

[3] "Collembola der Umgebung von Hamburg," 1896, p. 183.

[4] "Neue Collembolen-Formen aus Finnland," 1900, p. 9 (*Meddelanden af Societas pro Fauna et Flora Fennica*, h. 26).

Tetracanthella (sp.?).—A few specimens of a *Tetracanthella*—a genus not hitherto recorded from the British Isles—were found by me among sphagnum, at an elevation of about 2000 feet, on Ben Ledi, on 4th Sept. 1906; also at 2500 feet on Stuc-a-Chroin on 17th of same month. They do not appear to be Schött's *T. pilosa,* but further study is necessary to settle this.

Achorutes purpurascens, Lubb.—Carribber, Linlithgowshire, a few in moss, March 1902.

Triæna mirabilis, Tullb.—In March 1906 I found several examples of this minute species on the underside of a stone lying among decaying seaweed on the shore west of Aberdour, Fife.

Anurida maritima (Guer.), Laboulb.—Aberdour, April 1901, many floating on surface of rock pools; Dunbar, June. I find this species was recorded incidentally from the coast east of Dunbar, by James Hardy, as far back as 1848.[1]

Thysanura.

Præmachilis hibernica, Carp.—It appears that the Thysanuran recorded by Professor Carpenter and myself in our first paper (*l.c.*) as *Machilis polypoda* (L.) is not that insect, but another since described by Carpenter.[2] He has re-examined some of my specimens, and finds they belong to his new species.

At the Royal Botanic Garden, Edinburgh, I find a species of *Nicoletia,* and a small *Lepisma,* unlike anything I have seen before, apparently quite established, in one of the greenhouses.

Since submitting the foregoing paper to the Society I have discovered two further additions, as specified below, to the list of Collembola. These raise the number now known from this area to sixty-five.

[1] *Trans. Berw. Nat. Club*, ii. p. 286. *Machilis maritima* is also mentioned in the same paper.

[2] *Irish Naturalist*, 1907, p. 54. *Cf.* also my note in *Ann. S. N. H.*, 1907, p. 119.

Spring-tails and some other neglected groups have recently been engaging the attention of Mr R. S. Bagnall, Winlaton, Co. Durham, with excellent results. In a series of interesting notes, a printer's proof of which he has kindly shown me, communicated to the Entomological Society of London, he records five species of Collembola not previously reported from the British Isles. Among them are *Isotoma quadrioculata*, Tlb., from Durham, and *I. bidenticulata*, Tlb., from Northumberland and the west of Scotland. The former I have now the satisfaction of recording from Forth, and the latter is pretty sure, I think, to occur in the upper portion of the area. Indeed, there seems no reason why all the species reported by Mr Bagnall, and several others as well, should not occur with us at least locally.

The following are the two additions above alluded to: in their determination I have again had the kind help of Professor Carpenter.

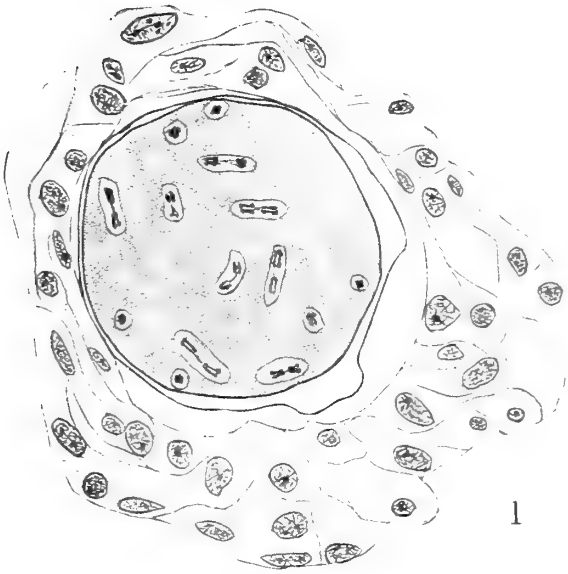
Isotoma quadrioculata, Tullb.—Out of some growing tufts of mosses and *Sedum anglicum*, got from the Isle of May in April this year, I obtained, along with abundance of *Isotoma arborea*, L., a considerable number of a smaller and greyer species, which proves to be the *I. quadrioculata* of Tullberg. As mentioned above, the species has only recently been added to the British list by Mr Bagnall. Abroad it is recorded from Sweden, Finland, Germany, Bohemia, Novaya Zemlya, etc.

Achorutes manubrialis, Tullb.—On 16th May this year, when looking for beetles under rotting "Canada weed" on the margin of Loch Leven (south side), I met with a few examples of this form. The name stands in the first list prepared by Carpenter and myself, but the subsequent examination of numerous specimens of the true *A. manubrialis* of Tullberg, from near Perth, showed us that the Edinburgh specimens were a different insect—see our second paper (*Proceedings*, Vol. XV.). It is a satisfaction, therefore, to be able to restore the name to our list. The species has been found on lake-shores in Sweden and Finland. Along with it at Loch Leven were innumerable examples of a small purplish variety of *Isotoma viridis*.

A tiny whitish *Sminthurus*, obtained this summer under a stone near Leadburn, was probably *S. cæcus*, immature.

Postscript, 29th July 1908 :—

Isotoma bidenticulata, Tullb.—I find that I have a specimen of this species taken in the glen of the Kelty, near Callander, on 17th Sept. 1906.



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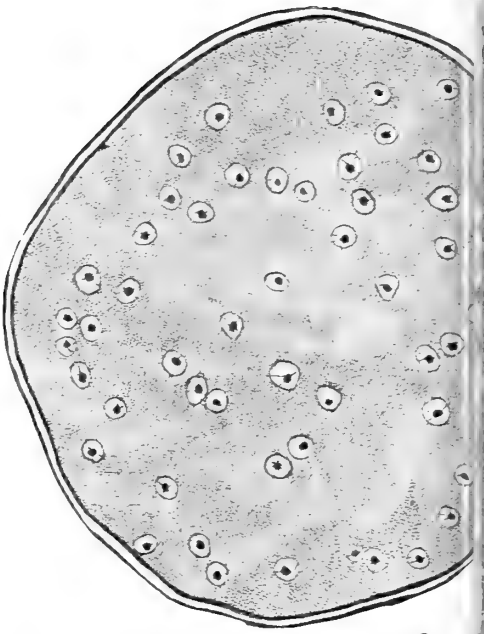

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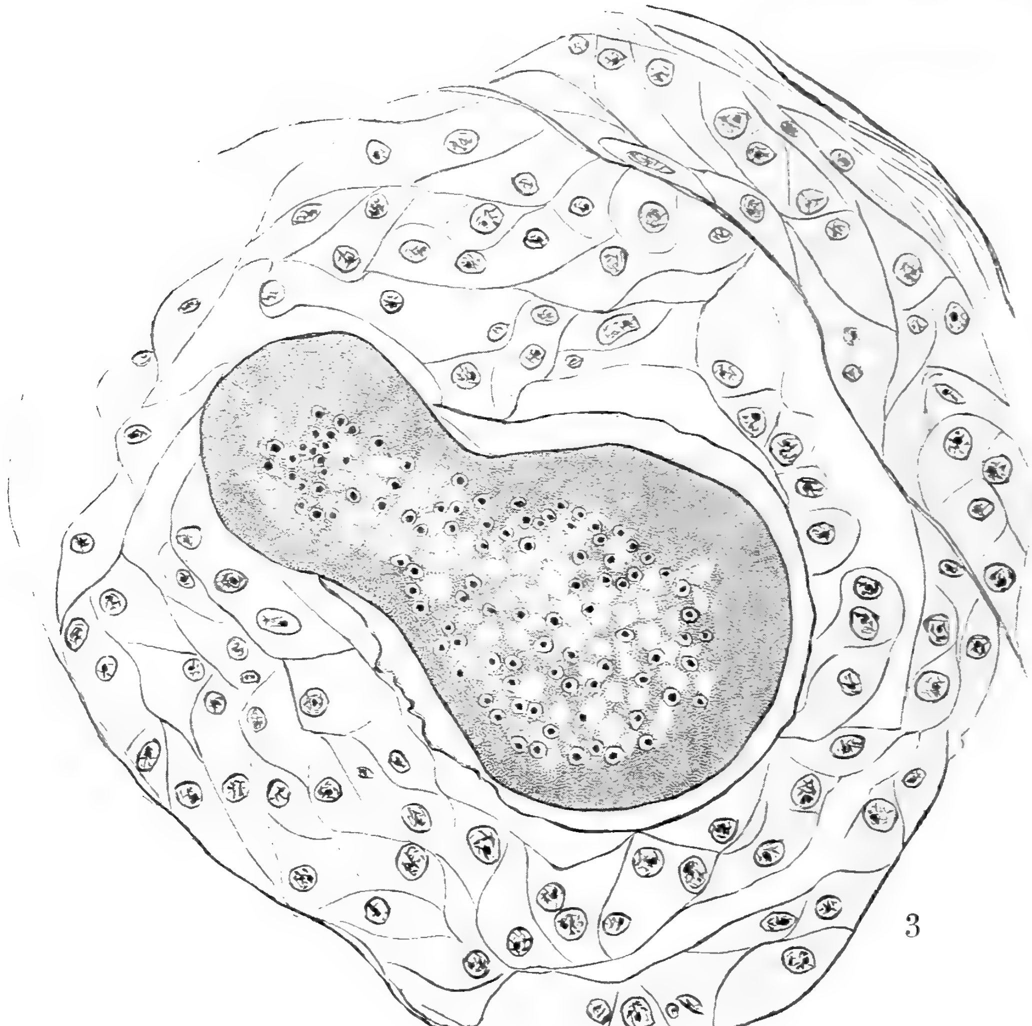

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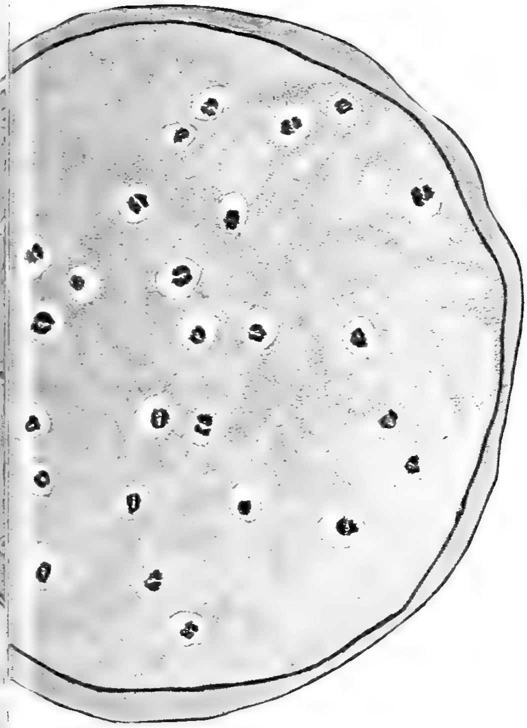

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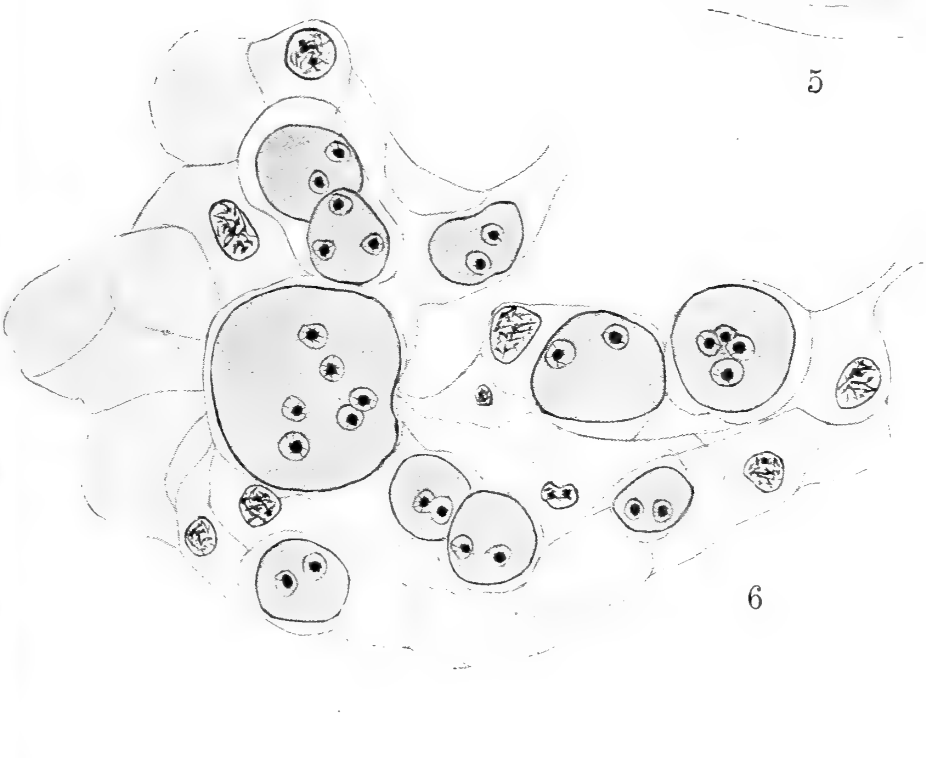

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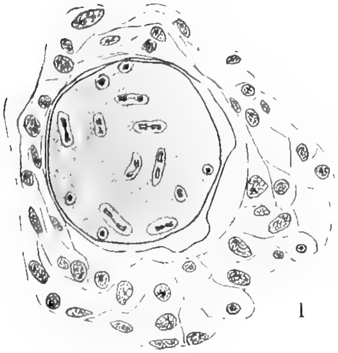

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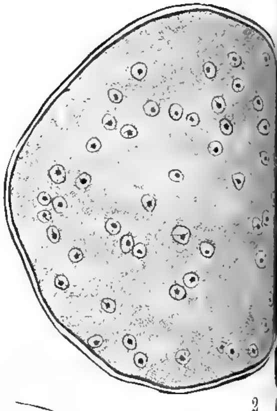

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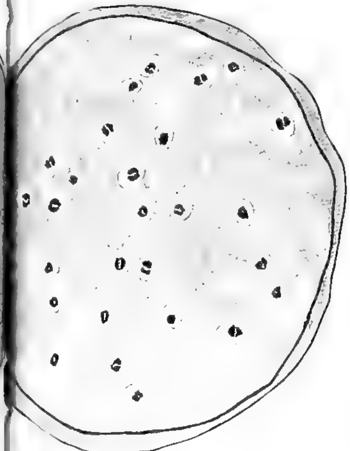

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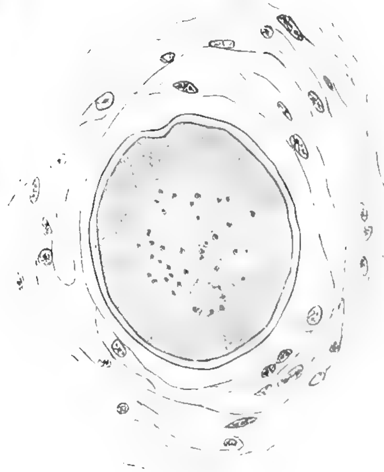

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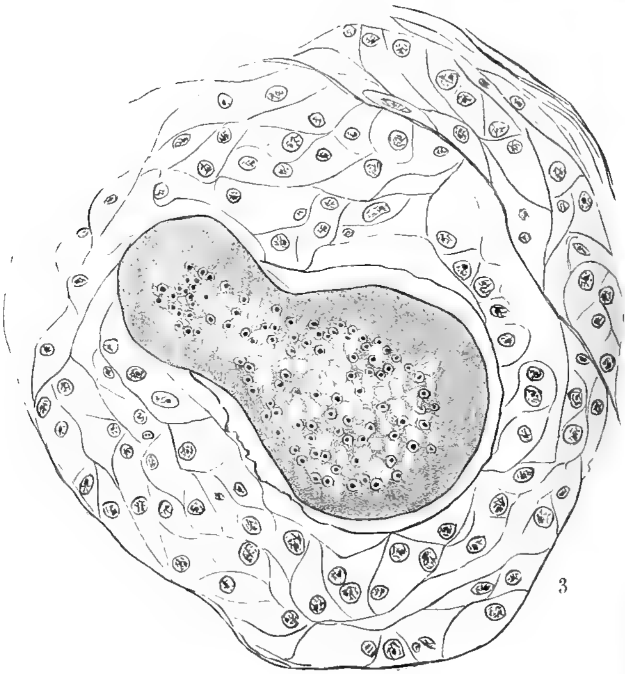

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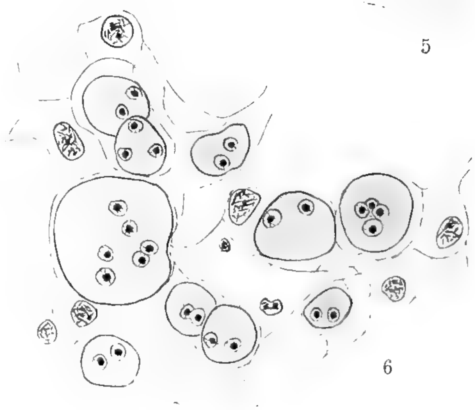

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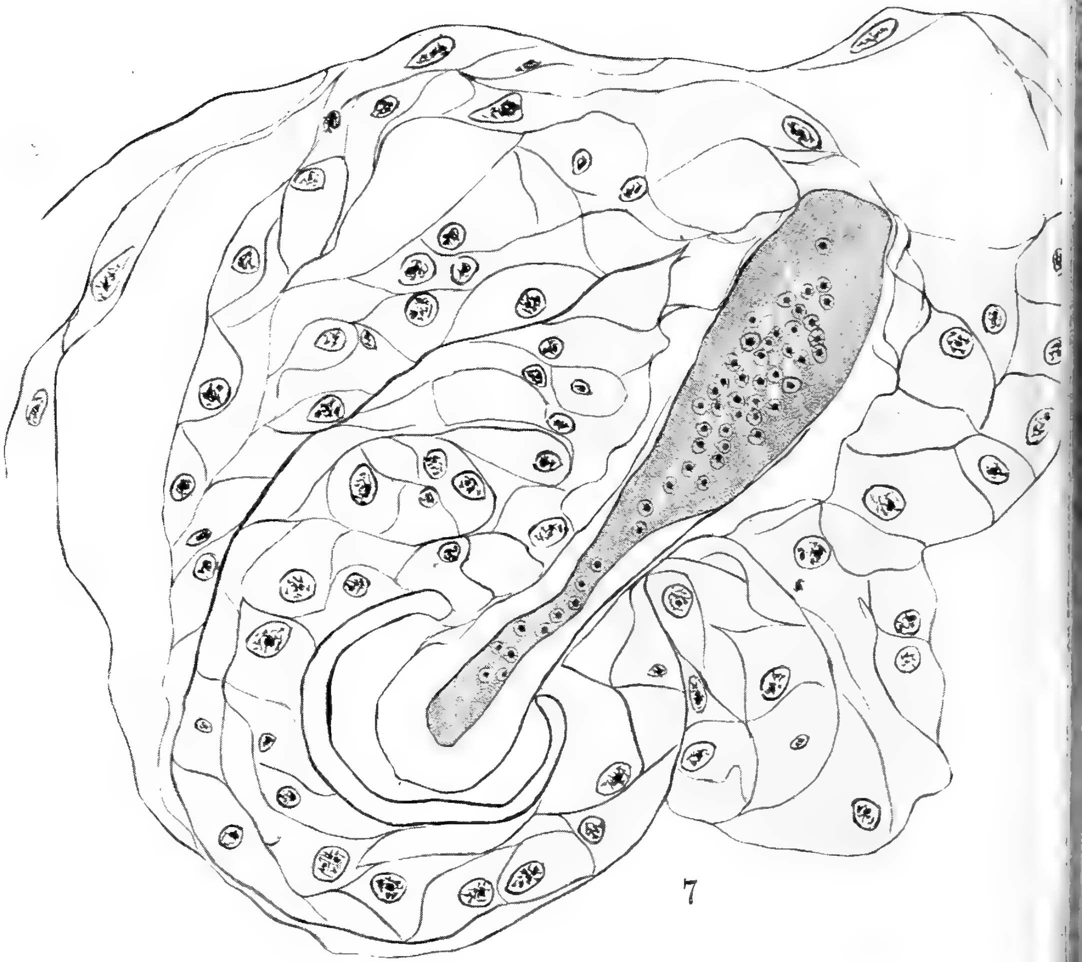

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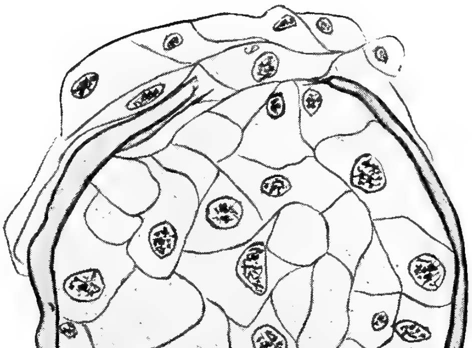

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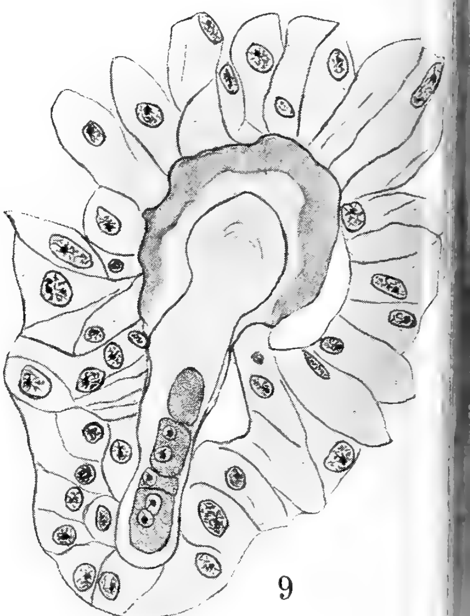

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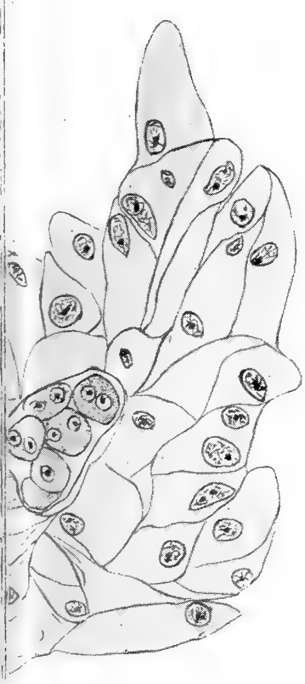

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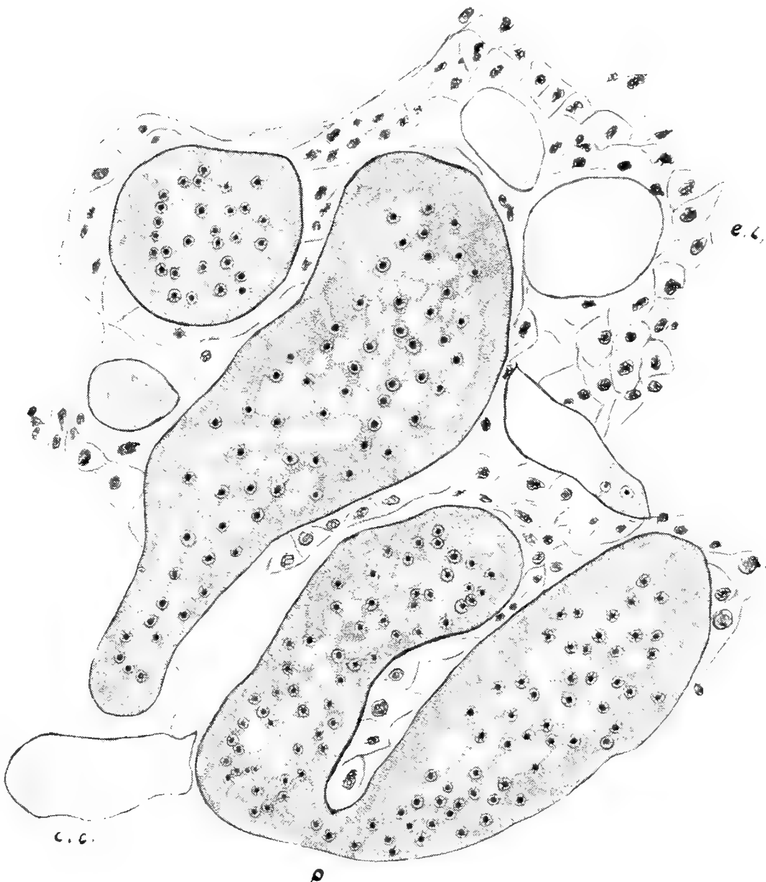

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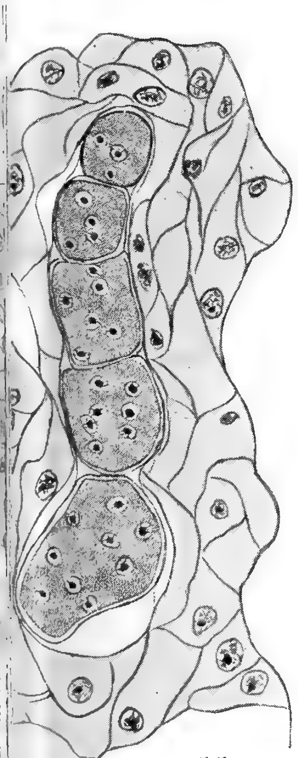

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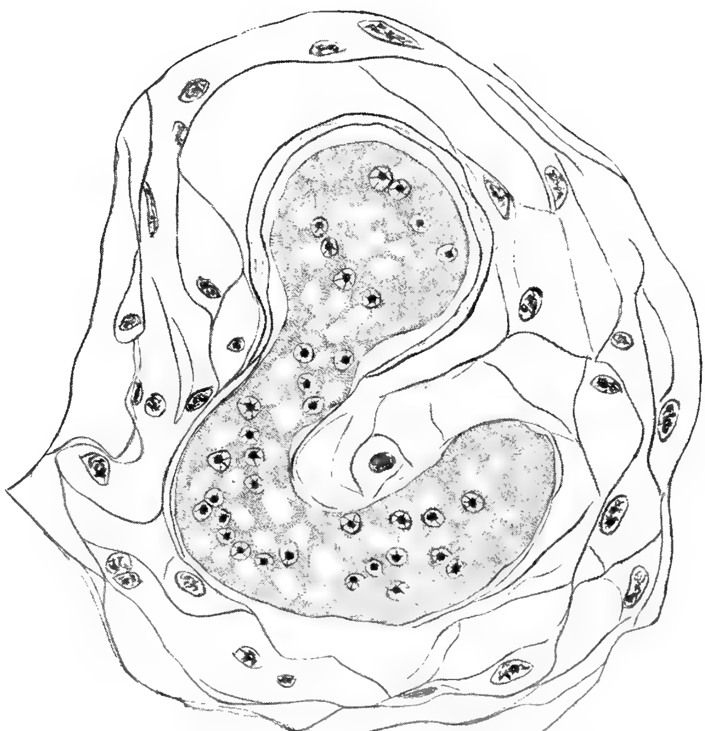

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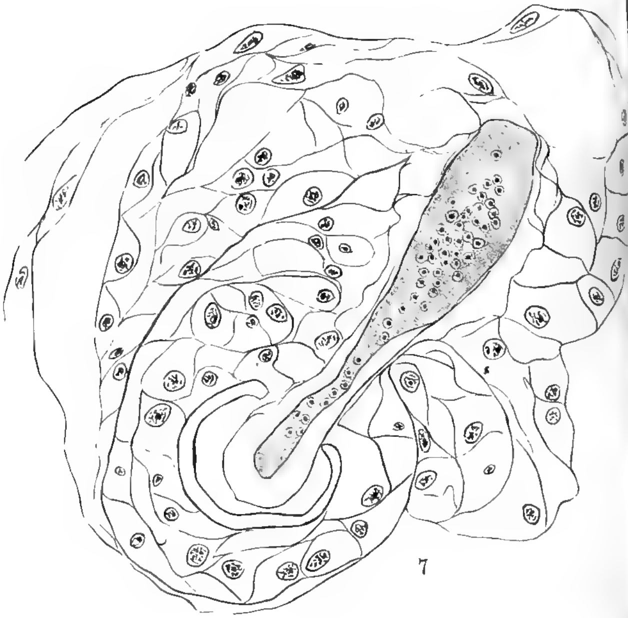

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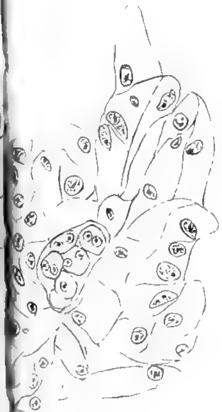

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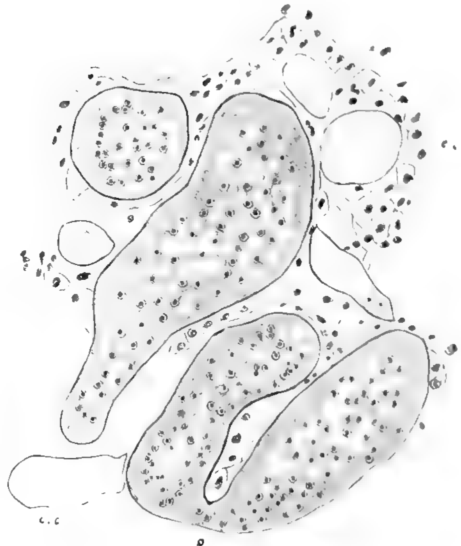

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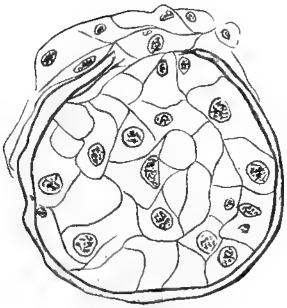

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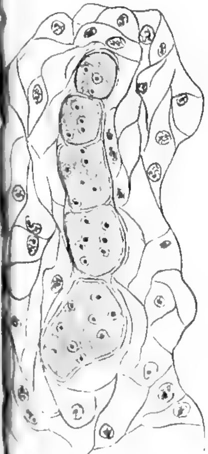

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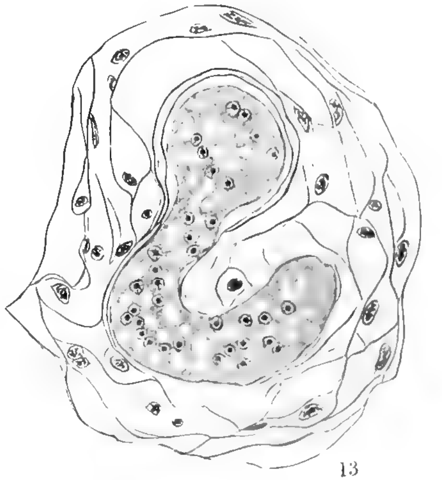

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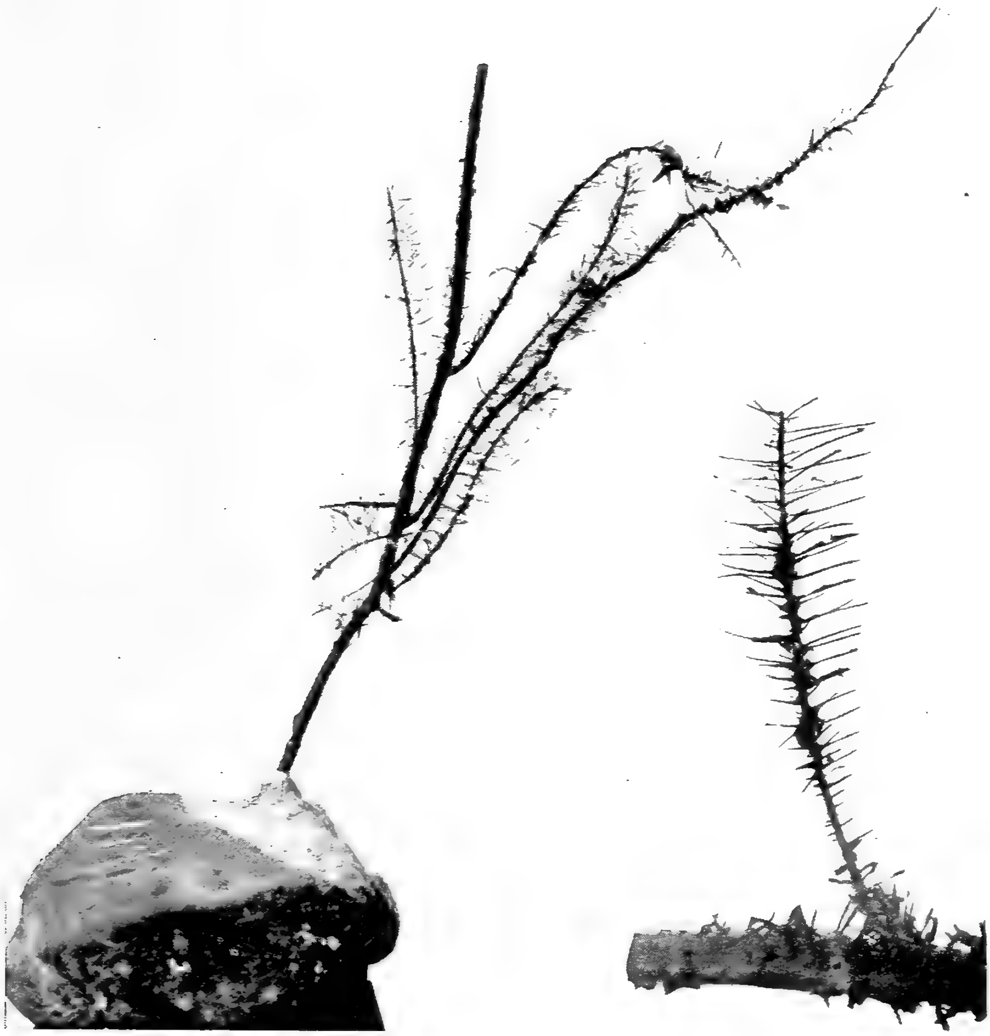

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XIX. *The Surface Details of the Bones of the Skeleton as an Index of Nutrition.* By A. Campbell Geddes, M.D., Demonstrator of Anatomy, University of Edinburgh. [Plate XII.]

(Read 23rd November 1908; received 16th December 1908.)

Introductory.

Everyone who has worked for a considerable period in the dissecting rooms of a great anatomy department, must have been struck by the extraordinary variation in the degree of development of the muscular impressions, crests, or tubercles which exist upon all the bones of the appendicular skeleton of the human body.

That these variations have not some meaning is inconceivable. That they are the expression of some underlying physiological process it is inevitable to conclude. Even partially to understand what this process is, it is necessary (first) briefly to review the existing beliefs with regard to the meaning of the bone crests and tubercles; (second) to consider some points in connection with the theory of growth; (third) to examine into the meaning of the histological phenomena of the process of ossification.

1. The Existing Beliefs with Regard to the Determination of the Secondary Characteristics of the Bones of the Appendicular Skeleton.

Topinard,[1] speaking of the sexual differences in the skeleton, says: "The principles which govern the sexual differences in adult age may be summed up in a few words. All the parts of the female skeleton are lighter and more frail; the general contour is more soft and graceful; the eminences, processes, or tubercles are smaller and less marked. If there be one well established physiological fact it is this—that the asperities which serve for the insertion of muscles are developed in proportion to the activity of those

[1] Topinard, *Anthropology.* Chapman & Hall, London, 1878, p. 143.

muscles. Less marked in the studious man than in the labourer, these asperities are still less so in the woman, especially in women residing in towns. This law is so exact, that we can tell by the degree of prominence of the crests and processes what muscles the individual was most in the habit of using, and hence judge as to his profession or calling. As a sequence of these prominences, the depressions, grooves, and marks are more distinct in the man." Further on he says: "A woman who had worked hard all her life would have the bony prominences and the processes for the articulations of muscles more developed, probably, than a man who had not worked at all."

This doctrine of Topinard's is practically universally believed and taught, and yet it is, on the face of it, impossible to regard the prominence of the bony ridges as inevitably associated with muscular action in view of the age differences in the bones of the skeleton described by Topinard on the same page. Speaking of the sexual differences in the skeleton, he says: "There is no appreciable difference in the skeleton in infancy, and up to puberty; its features are rather of a feminine character. At puberty, the line of demarcation commences, but the characters are not thoroughly defined until twenty years of age and upwards. At about forty-five, or upwards, the distinctions of sex become less marked, and at advanced age are but trifling, though the general character of the skeleton is rather masculine." It is, however, impossible to regard these statements of Topinard's as expressing the whole truth with regard to this matter, for if they be somewhat freely, but fairly, paraphrased, and a legitimate deduction be made from them, they read: "Prominence of eminences, processes, and tubercles upon the bones is associated with muscular action, and is in direct proportion to the activity of the muscles. The bones of old women show more marked ridges than the bones of young men, therefore, old women are more muscular than young men." Which is a true *reductio ad absurdum*. (See Fig. 1.) And yet it cannot be disputed that this time-honoured doctrine embodies at

least a part of the truth, and that the muscles do, through the strains and stresses which they throw on the bones, profoundly modify their general contour, and in many cases act as determinants of the sites of cresting and tuberculisation. And so it becomes necessary for us to seek a fuller explanation and interpretation of the meaning of these appearances—an explanation which will, on examination, prove less unsatisfactory than that of Topinard's.

In the course of this paper evidence will be produced which, I think, fairly conclusively demonstrates that the roughness of the bones of the appendicular skeleton is directly associated with, and is the permanent monument of, a relatively vigorous and even unfavourable type of metabolism, and that its apparent association with sex and age and muscular activity is in one sense accidental, and of value only so far as age and sex and muscular activity are themselves determinants of the prevailing type of metabolism.

It is not possible to proceed to the demonstration of this point without reviewing briefly the theory of growth.

2. The Theory of Growth.

(a) *The Growth of the Cell.*—Expenditure of energy is an essential characteristic of the living cell. This energy it derives from the food which it intussuscepts and uses to replace the de-energised matter within itself. But if there be food absorbed surplus to the actual needs of the moment, and if the surplus be retained, the cell, of necessity, is larger than before.

Now, Spencer has pointed out that as a sphere becomes larger its mass increases as the cube, its surface as the square of its diameter. The importance of this is obvious, for it means that the area of cell surface must become diminished relatively to the amount of cell mass, which, in turn, means that the difficulties in obtaining the non-storable parts of the food, as, for example, oxygen, and the difficulties of excretion must increase with the diminution

of facilities. It is, therefore, possible to say that as the cell grows "it must get into physiological difficulties, for the nutritive necessities of the increasing mass are ever less adequately supplied by the less rapidly increasing absorbent surface. The early excess of repair over waste secures the growth of the cell. Then a nemesis of growing wealth begins. The increase of surface is necessarily disproportionate to that of content, and so there is less opportunity for nutrition, respiration, and excretion. Waste thus gains upon, overtakes, balances, and threatens to exceed repair. Suppose a cell to have become as big as it can well be, a number of alternatives are possible. Growth may cease, and a balance be struck. On the other hand, waste may continue on the increase, and bring about dissolution and death; while closely akin to this there is the most frequent alternative, that the cell divide, halve its mass, gain new surface, and restore the balance."[1] This, restated in terms of protoplasmic activity, reads as follows: "The early growth of the cell, the increasing bulk of contained protoplasm, the accumulation of nutritive material, correspond to a predominance of protoplasmic processes which are constructive or anabolic. The growing disproportion between mass and surface must, however, imply a relative decrease of anabolism. Yet the life, or general metabolism, continues, and this entails a gradually increasing preponderance of destructive processes or katabolism. So long as growth continues the algebraic sum of the protoplasmic processes must be plus on the side of anabolism. The limit of growth, when waste has overtaken and is beginning to exceed the income or repair, corresponds in the same way to the maximum of katabolic preponderance consistent with life. The limit of growth is the end of the race between anabolism and katabolism, the latter being the winner.[2] Again restated, but this time in terms of the cell and its environment—Growth is primarily dependent upon the absorptive power which the cell

[1] Geddes and Thomson, *The Evolution of Sex.*

[2] *Ibid.*

possesses, or, in other words, upon the start which anabolism gets at the outset, but varies directly as the surplus of nutrition over expenditure, and directly as the rate at which this surplus decreases. The moment the surplus of nutrition over expenditure falls below zero the cell must die or divide. The moment division takes place the problem becomes complicated by the action of the laws governing the multiplication of living organisms.

(b) *The Laws of the Multiplication of Living Organisms.*—Before proceeding to discuss further the problems of growth, it is necessary, briefly, to state the laws of multiplication. The first of these is a modification of the law of Malthus. It reads: "A healthy population tends to increase to the limits of its food supply." The second is: "Since all living organisms have a fixed period to their individual existence, they must, in order to exist at all, establish with their environment an equilibrium sooner or later to be overthrown in death." The corollary of this is, "to prevent extinction the organism must meet the effects of its environment in two ways, by individual adaptation and by genesis." The third law is important: it is, "When favourable circumstances cause any species to become unusually numerous, competition becomes keener, and enemies that prey upon it more abundant." The fourth is: "In a species which survives, given the forces destructive of race as a constant quantity, those preservative of race must be a constant quantity also, and since the latter are two, the individual and the reproductive, these must vary inversely." To this law every species must conform or cease to exist. Tersely restated it reads, "Individuation and genesis vary inversely." The corollaries are (first) "Advancing specialisation must be accompanied by declining fertility;" and (second) "If the difficulties of self-preservation permanently diminish, there will be a permanent increase in the rate of multiplication, and conversely." [1]

(c) *Application of the Laws of Cell Growth and of Multi-*

[1] Geddes and Thomson, *The Evolution of Sex.*

plication to the Growth of a Multicellular Organism.—It is convenient here to draw attention to the importance of these laws of cell growth and of multiplication with regard to the growth processes of a multicellular organism.

From what has been said with regard to the growth of the cell, it follows that true hypertrophy, that is, increase in bulk of an organ or organism dependent upon an increase in the size of the component cells, their number remaining constant, depends upon an increase in the supply of food, or upon a supply of more absorbable food, or, that as a result of food already absorbed, the cell becomes more absorptive, in short, that as the result of a more favourable environment, the cell metabolism becomes relatively anabolic. Katabolic growth, that is, increase in cell numbers with reduction of cell size or relative increase of cell surface, has the exactly opposite environmental significance, and corresponds to a relatively less abundant supply of food, or a supply of less absorbable food, or to a diminished absorptive power.

All the somatic cells of a multicellular organism, however, belong to a race which, under ordinary physiological conditions, is doomed to become senile and ultimately extinct. This can be expressed in terms of metabolism as follows:—In a race of somatic cells there is, generation by generation, a reduction in the amount of the physiological energy of the individual cells, and consequently, although favourable nutrition may delay, it cannot prevent the ultimate death of the cells, in other words, the ultimate triumph of katabolism. This is the essential difference between a race of cells and a race of sexually produced multicellular organisms.

The application of the first law, a healthy population tends to increase beyond the limits of its food supply, is obviously affected by this law of ultimate katabolic triumph, because its intimate meaning is that a food supply, just equal to the demands of a colony of young, actively absorbing cells, will be inadequate for the same colony in old age, unless the cells have decreased in size, or assumed a

form of specialisation which makes little demands upon protoplasmic activity.

With regard to the second law of multiplication, it is only necessary to point out that for cells individual adaptation must mean specialisation which, by enabling the cell to procure an increased supply of blood, or to exist upon a diminished supply of blood, renders its environment more favourable.

The third law, "when favourable circumstances cause any species to become unusually numerous, competition becomes keener," is of importance, rather in connection with the limitation of growth.[1] Its meaning in terms of metabolism is obvious.

The fourth law, "individuation and genesis vary inversely," with its corollary, "advancing specialisation must be accompanied by declining fertility," is at the root of the phenomena of cytomorphosis,[2] for, histologically, it means that it is useless to expect to find an active, fully developed, highly specialised cell undergoing karyokinetic division. This opens up a field for the study of the life history of cells and of cell colonies.

With these facts and theories fresh in our minds, we are in a position to turn to an examination of the histology of ossification.

3. The Processes of Ossification in Terms of the Theory of Growth.

In order to avoid the appearance of consciously or unconsciously distorting the facts to suit the hypothesis, I propose to quote in full so much of a standard description of the process as is germane to the point at issue. For this purpose, I have selected the description of endochondral

[1] Cf. *Roux Der Kampf der Teile im Organismus*, Leipsic, 1881.

[2] The word cytomorphosis was introduced by Minot in 1901, "to designate comprehensively all the structural modifications which cells, or successive generations of cells, undergo from the earliest undifferentiated stage to their final destruction."

bone development, published in Piersol's *Human Anatomy*, Lippincott & Co., 1907, which possesses the merits of being authoritative and recent.

(a) *The Histology of Endochondral Bone Development.*—"The primary cartilage, formed by the proliferation and condensation of the elements of the young mesoblastic tissue, gradually assumes the characteristics of embryonal cartilage which, by the end of the second month of intrauterine life, maps out the principal segments of the foetal cartilaginous skeleton. These segments are invested by a primitive form of perichondrium or primary periosteum, from which proceed the elements actively engaged in the production of the osseous tissue. The initial changes appear within the cartilage at points known as centres of ossification, which in the long bones are situated about the middle of the future shaft. These early changes involve both cells and matrix which exhibit conspicuous increase in size and amount respectively. As a further consequence of this activity, the cartilage cells become larger and more vesicular, and encroach upon the intervening matrix in which deposition of lime salts now takes place.

"On acquiring their maximum growth, the cartilage cells soon exhibit indications of impaired vitality as suggested by their shrinking protoplasm and degenerating nuclei.

"Coincidentally with these intra-cartilaginous changes, a thin peripheral layer of bone has been formed beneath the young periosteum; from the latter bud-like processes of the osteogenetic layer grow inward from the periphery, and invade the embryonal cartilage; by absorption of the cartilage matrix they gain the centre of ossification, and there effect a destruction of the less resistant cells and intervening matrix. In consequence of the penetration of the periosteal processes, and the accompanying absorption of the cartilage, a space, the primary marrow cavity, now occupies the centre of ossification, and contains the direct continuation of the osteogenetic layer. This tissue, the primary marrow which has thus gained access to the interior of the cartilage, contributes the cellular elements

upon which a double role devolves—to produce osseous tissue and to remove the embryonal cartilage.

The cartilage matrix closing the enlarged cell spaces next the primary marrow cavity suffers absorption, whereby the cartilage cells are liberated, and the opened spaces are converted into the secondary areolae, and directly communicate with the growing medullary cavity. After the establishment of this communication, the cartilage cells escape from their former homes and undergo disintegration, *taking no part in the direct production of the osseous tissue.*

Beyond the immediate limits of the primary marrow cavity, the cartilage cells, in turn, repeat the preparatory stages of increased size and impaired vitality already described, but in addition they often exhibit a conspicuous rearrangement whereby they form columnar groups separated by intervening tracts of calcified matrix. This characteristic belt or zone of calcification surrounds the medullary cavity, and marks the area in which the destruction of the cartilage elements is progressing with greatest energy.

"Simultaneously with the destructive phase attending the absorption of the cartilage, the constructive phase is instituted by the osteoblasts by which the bone tissue is formed. These specialised connective tissue elements resting upon the irregular trabeculae of the calcified cartilage bring about, through the influence of their protoplasm, the deposition of a layer of bone matrix upon the surface of the trabeculae, which thus becomes enclosed within the new bone. After the latter has attained a thickness of at least the diameter of the osteoblasts, some of the cells in closest apposition are gradually surrounded by osseous matrix, until finally they lie isolated within the newly formed bone as its cells; the bone cells are, therefore, imprisoned osteoblasts which in turn are specialised connective tissue elements."

We shall now consider, in the light of the theory of growth, what all these extraordinary processes mean.

(b) *The Process of Ossification in Terms of the Theory of Growth* (see Fig. 2).—During the second month of intra-

uterine life, the young mesoblastic cells which are placed in the axes of the limbs are so crowded together that they become condensed. This we may well believe leads to difficulties in obtaining adequate nutrition, and in carrying on the necessary processes of cell life, and so, conforming to the laws of multiplication of living organisms, individual adaptation is substituted for rapid genesis. The specialisation is in the direction of the formation of cartilage cells, and by them the embryonal cartilage is formed. It is beyond the limits of the present paper to discuss the reason why these cells specialise as chondroblasts.

The older cells of the embryonal cartilage, that is to say, those situated about the centre of the bone shaft-to-be, gradually, but progressively hypertrophy, and by their hypertrophy mark histologically the centre of ossification. The meaning and results of this hypertrophy are interesting. The cells are in some measure specialised, and have, therefore, according to the theory of growth lost, in part at least, their power of genesis. Their hypertrophy tells us that their anabolism is in excess of their requirements, that their environment is favourable; but it is too favourable, and, unable to divide, they increase in size until the nemesis of cell growth overtakes them, and they degenerate and die, because their surface is too small to support the contained mass.

The matrix in the neighbourhood, unrefreshed by the activity of the cells, degenerates, and lime salts are deposited in it. This interpretation of the meaning of the calcification of the cartilage matrix, brings it into line with the pathological calcifications, "which occur almost without exception in degenerating, dying, or dead tissue."[1] This, in terms of the theory of growth, is the meaning of the histological fact that, "on acquiring their maximum growth the cartilage cells soon exhibit indications of impaired vitality, as suggested by their shrinking protoplasm and degenerating nuclei."[2] As the chondroblasts die out,

[1] Hektoen and Reisman, *Text-Book of Pathology.* Saunders, 1901, p. 113.

[2] Piersol, *loc. cit.*

the cells of the osteogenetic layer of the primitive periosteum rapidly multiply and topographically replace their predecessors.

It is convenient here to digress for a moment to consider what these phenomena mean from the point of view of the cartilage cells.

In some of the lower animals, the skeleton remains cartilaginous throughout life. In other words, the supply of nutrition to the cells is balanced so that a specialised cartilage cell just receives sufficient nutriment to enable it to perform its function of keeping the cartilaginous matrix refreshed and healthy, whereas, in the higher animals, as in man, the supply of nutrition is more than the cells can profitably use. Overfed, they increase in bulk, the increase of surface is necessarily disproportionate to that of content, and so there is less opportunity for nutrition, respiration, and excretion. Waste gains up, overtakes, balances, exceeds repair, and brings about dissolution and death.[1]

To resume; the cells from the osteogenetic layer penetrate right to the centre of, and there absorb the cartilage, eating out a space, the primitive marrow cavity, which they occupy, and in which they proliferate to form a tissue, the primitive marrow. From this there arise the cells which are known in histology as the osteoblasts and the osteoclasts. Around the primitive marrow cavity the surfeit and the death of the cartilage cells continue, but before the cells attain to their fatal specialisation the safety of the race has been temporarily, at least, provided for by genesis, one of the daughter cells apparently always escaping to the side of less pressure, that is, to the side where the cells are still smaller. The result of this is seen histologically in the almost columnar arrangement of the cells. Between the columns the matrix, unrefreshed by its guardian cells, which have died or are dying, undergoes calcification. As a result, the edge of the dying cartilage is serrated by the advancing swarm of osteoblasts; the dead bodies of the

[1] V. S.

cartilage cells being more easily absorbed than the intervening columns of calcified matrix.

While this process of removal of the unsuccessful cartilage is in progress, the rapidly multiplying cells of the successful race begin to feel the pinch of shortening food supply, and specialisation is forced on. The specialisation adopted is designed to enable the cells to avoid increasing the amount of their protoplasm, and to enable them healthily to exist upon a supply of nutriment formerly inadequate. Histologically they now appear as small cells which secrete a mineral envelope. Thus is formed the primitive central spongy bone. In the course of time, however, the cells begin to suffer, even their specialisation is insufficient to ensure due economy, and they and their bony envelopes are removed by the osteoclasts.

It is unnecessary to follow out all the changes leading to a higher and higher specialisation towards economy, which are undergone before the adult bone is formed, but the type of the adult osteoblast is important. Its specialisation is all towards reduction of mass and increase of absorbing surface. The fact that it gets rid of a large part of its absorbed nutriment rather than adds to its bulk, is evidence that it can deal with nutriment in excess of its momentary needs; its flattened shape, with its numerous branching processes, is typical of a cell prepared against a threatened food shortage, for the flat surfaces and branching processes yield far more surface per unit of mass than could be given by any shape approaching the spherical.

The conclusions, consequent upon this interpretation of the phenomena of ossification are—(first) the cartilage cells of the primitive shafts of long bones are little able to endure high nutrition, and are, in the higher animals, soon destroyed by their own excessive growth; (second) all osteoblasts are specialised to ensure economy of nutrition, but they are not adversely affected by high nutrition, as they have acquired the power of excreting a great part of their absorbed nutriment. From these conclusions it follows that in conditions of high nutrition, so long as the epiphyseal plates persist the

cartilage cells will proliferate rapidly, and increase in the length of bones will result; and that in conditions of lower nutrition only the osteoblasts will be able to proliferate, and increase in the diameter of bones will result. Restated, anabolic conditions determine macroplasia, or growth in length; katabolic conditions, euryplasia, or growth in circumference.

(c) *Mechanism of Macroplasia and Euryplasia.*—Macroplasia is the result of a highly nutritive environment. The reason for this appears to be that the fully specialised cartilage cell is too absorptive, is too anabolic, to cope with a large supply of food. Individuation and genesis, however, vary inversely; and, from the point of view of the cartilage cells themselves, individuation is low, therefore, genesis is high. In result the cartilage grows rapidly, but is rapidly replaced by bone; the limb bones increase in length, and, because of the high level of chondro-genesis, the epiphyseal plates persist. On the other hand, the individuation of the osteoblasts is successful, that is, is relatively high, therefore their genetic energy is reduced, and there is little tendency to unnecessary bone formation. But the specialisation of cartilage cells is not only unsatisfactory from the point of view of their resisting the action of a too favourable environment, it is also unsatisfactory in that it does not give a sufficiently wide margin to permit them to prosper in an unfavourable environment; this is clearly shown by the calcification of the cartilages of old men, and it explains the early disappearance of the epiphyseal plates in poorly nourished individuals. Cartilage cells are, therefore, to be looked upon as imperfectly specialised. On the one hand, they are not economical cells; on the other hand, they perform no very active functions, and are, therefore, unable to use up much of the potential energy of their food supply; in short, they are primitive organisms which in the race of evolution have been left hopelessly behind by the osteoblasts. Phylogenetic as well as ontogenetic evidence supports this conclusion.

Further, in a lowly nutritive environment, euryplasia must occur, for there is no rapid multiplication of cartilage re-

placing cells to be provided for out of the blood supply of the developing bone; in other words, the individuation of the osteoblasts is only moderately successful, is relatively low, and therefore osteogenesis is high.

Without the scaffolding provided for them by the cartilage, the osteoblasts cannot add much to the length of the bone, they, therefore, add lamina after lamina to its circumferences. In such conditions, as a subsidiary, and, in large measure, as an accidental factor, the effects of muscle activity are felt by the bone cells as determinants of areas of osteogenetic hyper-activity. The areas of myo-osseous and tendino-osseous articulation are in a sense areas of irritation, the contraction and relaxation of the muscle imposing intermittent strain upon the periosteum, which, in turn, through the application of a well-known physio-pathological law is known to lead to increased vascularity. The increased vascularity increases the available supply of nutriment, and leads to a particularly active euryplasia in the areas of myo-osseous articulation.

Further, the more intense within limits the general food shortage is, the more intense will be the osteogenetic activity; because, as the success of individuation diminishes, the activity of genesis increases.

The conclusion, therefore, is that smooth and graceful bones are associated with favourable nutritive conditions, with free endochondral ossification; that rugged, strongly-marked bones are associated with what are, from the point of view of the cell, relatively unfavourable nutritive conditions, with free periosteal ossification.

(d) *The Metabolism of the Male compared with the Metabolism of the Female.*—The expenditure of energy by the male is normally greater than the expenditure of energy by the female, and as a result the metabolism of the male is normally more vigorous, more katabolic, than that of the female. The proof of this statement is wide-based on physiological, psychical, and biological facts, and I propose to hold it as, in the main, established.

It is now possible to state, in terms of metabolism, the

laws which govern the age-sex characteristics of the bones of the appendicular skeleton.

(e) *The Age-Sex Characteristics of the Skeleton in Terms of Metabolism.*—At the beginning of this paper, the following passage was quoted from "Topinard's *Anthropology:* "There is no appreciable difference in the skeleton in infancy. and up to puberty; its features are rather of a feminine character. At puberty, the line of demarcation commences, but the characters are not thoroughly defined until twenty years of age and upwards. At about forty-five, or upwards, the distinctions of sex become less marked, and at advanced age are but trifling, though the general character of the skeleton is rather masculine."

This statement rewritten in terms of metabolism, reads: "There is no appreciable difference between the surface texture of the bones of the male and female skeleton either in infancy, or up to puberty, its features indicating a metabolism of a favourable nutritive type. At puberty, the line of demarcation commences. The metabolism of the male becomes more vigorous, in other words, more katabolic. This condition renders the individuation of the osteoblasts incompletely successful, and consequently genesis is stimulated particularly in regions of considerable vascular supply, such as the myo-osseous articulations. A limited euryplasia results, and the bones become crested and tuberculated. The metabolism of the healthy female, on the other hand, remains predominantly anabolic, and the adjustment of the osteoblastic individuation to its environment is undisturbed. Genesis is not stimulated, and the normal euryplasia continues slight and in great measure uniform.

In middle life, the anabolic power of all the somatic cells normally tends to diminish. To this law the osteoblasts are no exception, and the adjustment of their individuation to their environment is disturbed or further disturbed. Genesis is stimulated, and, as before, a limited euryplasia results; and necessarily the bones tend to become rougher and more marked at the sites of muscular attachment.

Abnormally, as the result of overwork causing excessive

expenditure of energy, or of starvation, or of malnutrition dependent upon some pathological condition, the environment of the body cells may become markedly less favourable, and therefore, and this is really the same statement, their individuation will be less satisfactory. As before, genesis will be stimulated, and euryplasia will be determined.

In extreme old age the sites of myo-osseous articulation cease, in some measure, with the ceasing activity of the muscles to be sites of increased periosteal irritation and vascular supply. In all the tissues of the body the anabolic power of the cells is declining, their genetic power is almost exhausted, and absorption, which in the bones leads to osteoporosis, becomes an important modifying factor, and the more outstanding crests and tubercles become smoothed down or rounded off.

And so we reach the interesting, and, I think, not unimportant conclusion, that the surface details of the bones of the skeleton are only indirectly dependent upon age and sex and muscular activity; and are not, as Topinard thought, and as is still taught, an index of the absolute muscularity of the individual, but are directly dependent upon, and primarily are an index of the type of nutrition which the somatic cells enjoyed.

XX. *Is the Hydroid,* Selaginopsis mirabilis, *a native of British Seas?* By JAMES RITCHIE, M.A., B.Sc., Natural History Department, the Royal Scottish Museum.

(Read 21st December 1908; received 22nd February 1909.)

During the present autumn I received from Mr John Thompson, Hull, three colonies of a Hydroid which I have identified as *Selaginopsis mirabilis* (Verrill, 1872). The specimens were obtained by Mr Thompson in March 1907, during one of his searches among the zoological refuse in the nets of trawl-boats lying at Hull. The vessel, in the net of which the colonies were found, had taken its last few hauls off Flamborough Head, the depth at that place being between 30 and 35 fathoms, and the bottom sandy with occasional loose stones. The colonies were growing on a loose stone covered with *Serpula* tubes, but they had to be torn from it owing to the impossibility of abstracting the stone through the mesh of the net. That the specimens were attached to so solid a foundation, however, is of some importance, for it excludes the chance of their having drifted to the locality where they were found, and points clearly to their occurrence *in situ.* When found the colonies were "in fine condition, absolutely fresh," and, even dried, they are good examples of the species, 11, 13·5, and 14·3 cm. high respectively, with complete pinnæ and many gonangia.

For long *S. mirabilis* was regarded as a strictly Arctic species, but recent investigations show that its range extends into temperate and even sub-tropical waters. Thus both Nutting[1] and Torrey[2] have recorded it from Puget Sound, on the Pacific Coast of America, while Nutting has found it as far south as lat. 34° 45′ 20″ N., long. 75° 38′ 10″ W., that

[1] Nutting, C. C., "Hydroids from Alaska and Puget Sound," *Proc. U. S. Nat. Mus.*, xxi., 1899, p. 741.

[2] Torrey, H. B., "The Hydroida of the Pacific Coast of North America," *Univ. California Publications*, *Zool.*, vol. i., 1902, p. 70.

is, off the coast of Carolina.[1] There is therefore no reason, on general grounds, why the species should not occur in our temperate seas, notwithstanding that on the eastern side of the Atlantic the farthest south records are from Iceland[2] and Tromsö.[3]

On the following grounds, therefore, I venture to suggest that *Selaginopsis mirabilis* is a native of British seas. Specimens have been found in the net of a trawl-boat which had taken its last few hauls off Flamborough Head. These specimens were almost certainly picked up in these last hauls, because:—

(1) They were "absolutely fresh" when landed at Hull.

(2) The perisarc was in good condition; the pinnæ were unbroken, and bore many delicate gonangia. (Had the specimens been dragged in the net time and again over the sea-bottom in successive hauls, considerable damage would have been done to structures so fragile.)

(3) The colonies were growing on a stone. It is extremely unlikely that a stone would have been retained in a net whose "cod-end" had been opened to allow the escape of the "catch."

That some shred of doubt will always cling to a trawler-made record is perhaps inevitable; but I have mentioned the occurrence of the specimens partly that collectors may be on the outlook for this fine species which, on casual examination, might easily be rejected as the not uncommon *Thuiaria lonchitis* (Ell. and Sol.) [*Th. articulata* of Hincks's "British Hydroids"].

Notes on the Specimens.—The following variations have been observed. In one case, where the distal portion of a gonangium had become broken, the position of the reproductive cœnosarc has been usurped by a vegetative bud, with the result that a branch springs from the lumen of the

[1] Nutting, C. C., "American Hydroids: the Sertularidæ," *Smithsonian Instit.*, *Special Bull.*, 1904, p. 128.

[2] Sæmundsson, B., *Bidrag til Kundskaben om de Islandske Hydroider*, 1902, p. 63.

[3] Bonnevie, K., "Neue norwegische Hydroiden," *Bergens Mus. Aarbog*, 1899, p. 12.

gonangium (Fig. 1). This short branch is abnormal in bearing, instead of six rows of hydrothecæ, only four rows, each hydrotheca-pair being set at right angles to the pairs immediately above and below it, as in *Staurotheca.* Such a meristic variation, which represents the normal development of *Selaginopsis cylindrica* (Clark), where the proximal

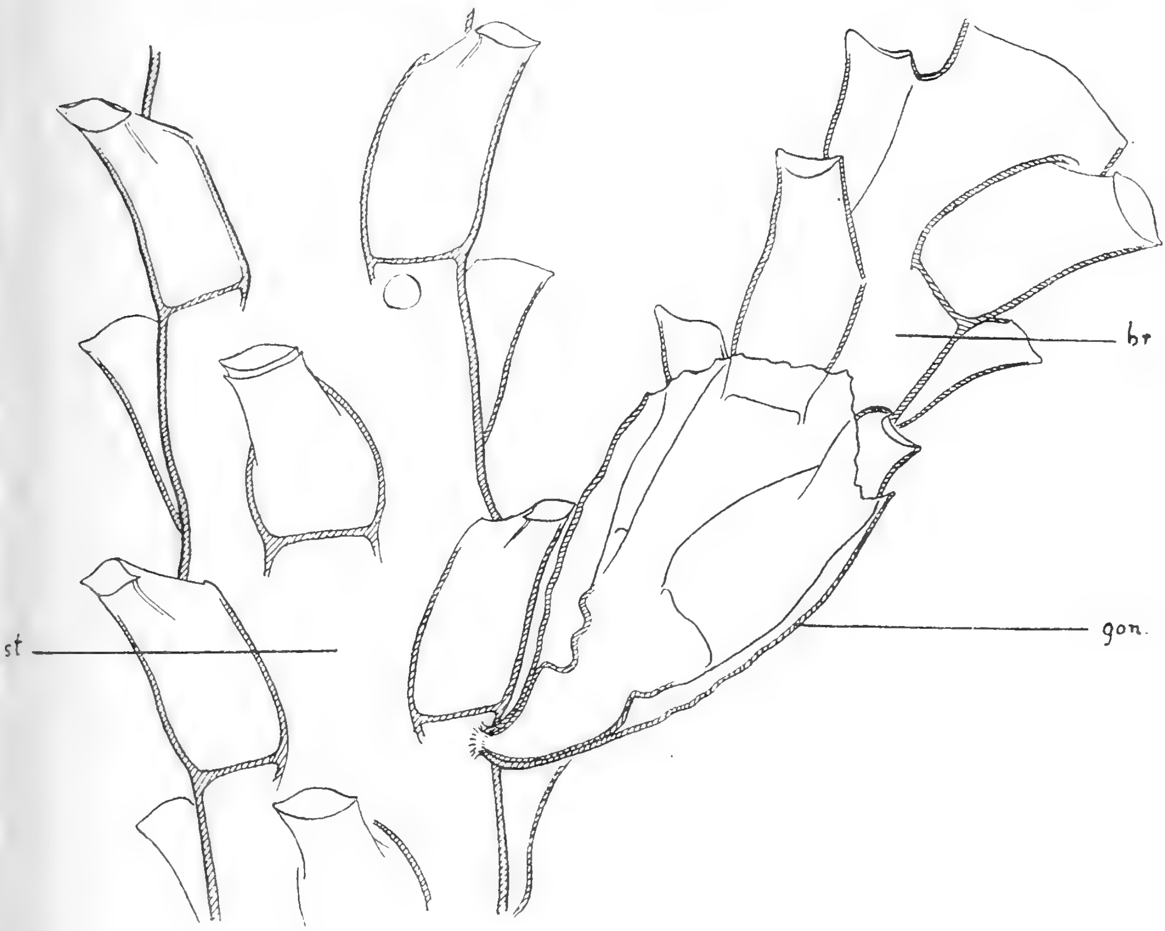

Fig. 1. Portion of stem of *Selaginopsis mirabilis*, with branch arising from interior of gonangium. × 40. st. = stem ; br. = branch ; gon. = gonangium.

portions of the branches bear four rows of hydrothecæ, the distal six (or rarely eight), is unusual in *Selaginopsis mirabilis*, although in this species also there is occasionally manifested a tendency for the hydrothecæ situated at the base of the branches to be fewer in number and less definite in arrangement than those further from the origin.

A duplicated hydrotheca represents a type of variation which I have not hitherto observed in Hydroids. A single hydrotheca is replaced by two (Fig. 2), but the cavities of the twin cells are continuous, although a partition running

backwards from the abcauline wall partially divides the one from the other. The orientation of the twins differs from

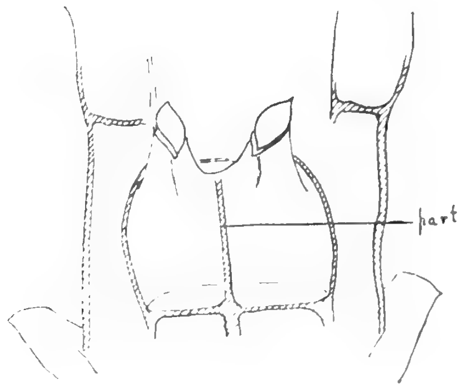

Fig. 2. Twin hydrothecæ of *Selaginopsis mirabilis*. × 40. part. = partition.

the normal, for the marginal teeth instead of being lateral are adcauline and abcauline.

Two epizoic Hydroids occurred creeping over the colonies, *Filellum serpens* (Hassall), and *Campanularia volubilis* (Linn.).

XXI. *Note on the Probable Origin of the Hydroid Genus* Selaginopsis. By JAMES RITCHIE, M.A., B.Sc., Natural History Department, the Royal Scottish Museum.

(Read 21st December 1908; received 22nd February 1909.)

That the connection between *Selaginopsis* and *Thuiaria* is a close one is evident from the similarity of their species in general habit, from the resemblance of their gonangia in shape, and from the almost universal occurrence in each of a simple abcauline operculum. The degree of the relationship, however, has been a matter of doubt.

Prof. C. C. Nutting considers that "the affinities [of *Selaginopsis*] are evidently with *Thuiaria*, from which, however, it is sharply differentiated by the arrangement of its hydrothecæ." [1] In 1902 Mr H. B. Torrey described as belonging to the *Thuiaria* group of the genus *Sertularia* a species, *Sertularia incongrua*—characterised by possessing two rows of hydrothecæ on the proximal portions of the branches, three on the distal—which he regarded as showing a "transition from the *Thuiaria* to the *Selaginopsis* type." [2] Nutting, however, regards this species as identical with the *Selaginopsis triserialis* of Mereschkowsky, and seems to cast doubt on the idea of intergradation, on account of the fact that "several species of *Selaginopsis* . . . have but two rows of hydrothecæ on the proximal part of their branches, the other rows being intercalated distally."

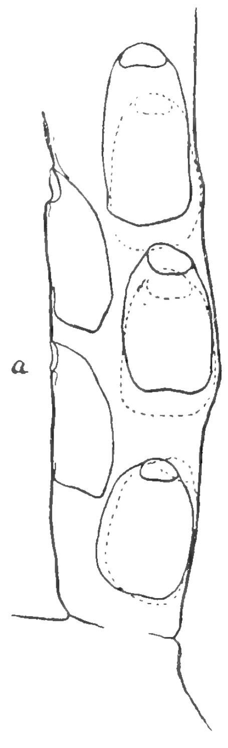

Fig. 1. Abnormal branch of *Thuiaria thuja* (L.), with three series of hydrothecæ. × 40. *a*, upper surface.

Recently a slide containing a fragment of a Hydroid specimen has been given me by the Rev. J. Waterston, and this appears to aid in linking together the two genera. The fragment is part of the stem of a young

[1] Nutting, C. C., "American Hydroids. Pt. II., The Sertularidæ," *Smithsonian Institution, Special Bulletin*, 1904, p. 127.

[2] Torrey, H. B., 1902, "The Hydroida of the Pacific Coast of North America," *Univ. California Pub., Zool.*, vol. i. p. 69.

pinnate colony of *Thuiaria thuja* (Linn.)[1] bearing fifteen alternate branches, twelve of which are normal in every respect. The remaining three follow each other on one side of the stem at its distal end. Of these the proximal two are typical in structure, but abnormal in orientation, for the hydrotheca rows, instead of lying in the vertical plane which contains stem and branches, lie in a horizontal plane cutting the stem at right angles. The rows, as if to prepare for the next step in a progressive variation, are placed rather on the lower side of the middle of the branch. The abnormal branch last to develop resembles its immediate predecessors except that an additional row of hydrothecæ has been interpolated on the upper surface. This branch, then, exactly resembles those of *Selaginopsis triserialis* where three series of hydrothecæ are present. Further, Bale has described and figured a similar variety of the Australasian *Thuiaria* (*Sertularia*) *unguiculata* (Busk), a species which belongs to the genus *Thuiaria*—as defined by Nutting, 1904—on account of the presence of more than one pair of hydrothecæ on many internodes, the hydrothecæ, where several occur together, assuming an alternate or sub-alternate arrangement. The most remarkable feature of this variety "is the presence on some of the pinnæ of a third series of hydrothecæ, running for some distance along the front of the first internode," and Bale regards this as showing a transition towards *Selaginopsis*.[2] While great stress cannot be laid on an occasional meristic abnormality, these variations, taken together with the existence of such a form as *S. triserialis*, seem to point to one of the paths which phylogenetically connect *Thuiaria* with *Selaginopsis*. Since, moreover, *Selaginopsis* colonies pass through a *Thuiaria*-stage in early development (they, indeed, always retain a *Thuiaria* stem), and since they are more liable to variation—less stable in structure—than *Thuiaria* colonies, it may be assumed that of the two types *Thuiaria* is the older and better established, and that therefore from it *Selaginopsis* has been evolved.

[1] Dredged by Mr Waterston, off the Bell Rock, 30th August 1904.

[2] Bale, W. M., *Catalogue of the Australian Hydroid Zoophytes*. Sydney, 1884, p. 77, pl. vi. fig. 9.

XXII. *On* UNIONICOLA Hald., *as a Valid Generic Name.*

By WM. WILLIAMSON.

(Read 22nd March 1909; received 24th March 1909.)

For many years *Atax* F. was considered to be a valid generic name until in 1897 A. C. Oudemans pointed out that it was only a synonym of *Hydrachna* as established by O. F. Müller. Nevertheless, *Atax* F. retained generic rank until 1905 when Wolcott rejected it and substituted *Unionicola* Hald. for it. The facts leading up to this may be briefly stated as follows:—Linnæus apparently intended *Acarus aquaticus* as a name for water-mites in general but later it was restricted to a species now known as *Limnochares aquaticus* (L.). This species, however, was not included by O. F. Müller among the forty-nine species described and figured by him and for which he established the generic name *Hydrachna*. J. C. Fabricius evidently did not recognise *Hydrachna*, as in 1793 he included among the Trombidiums thirty-three of Müller's species and also the *Acarus aquaticus* of Linnæus. Latreille in 1796 divided Müller's *Hydrachna* into two genera, viz., *Hydrachna*, with *H. cruenta* Müll., as type, and *Eylais*, with *H. extendens* Müll., as type. To these two genera was added another, *Limnochares*, with *Acarus aquaticus* L., as type. In 1805 J. C. Fabricius removed the water-mites, with the exception of *Acarus aquaticus* L., from *Trombidium* and placed them in his new genus *Atax*. In 1834 Dugès restricted *Atax* and selected as types for it the *Hydrachna histrionica* and *H. lutescens* of Hermann. In 1842 Haldeman described nine species of water-mites, all of which, he states, "without exception, are found upon, or between the branchiæ, or between the branchiæ and the body of the Unionidæ." For these he proposed the generic name of *Unionicola*. *U. oviformis* Hald. appears to be the same species which Bonz earlier described as *Acarus ypsilophorus*.

From 1835 to 1841 C. L. Koch added several vaguely described species to the genus *Atax* but he did not give

any definition to the genus until the appearance of his "Übersicht" in 1842. Here he defined *Atax* differently from Dugès, giving to the name the definition which was extended by Bruzelius in 1854, and this remained unchallenged until Oudemans and Wolcott took up the position referred to.

It is evident that Fabricius considered *Atax*, for which he designated no type, as an equivalent of *Hydrachna* Müll., since he quoted the latter as a synonym. *Hydrachna* Müll., being the older name, has a right to priority, to which, moreover, Latreille's genera are also entitled, both on account of their earlier date as well as for their designation of types. Apart from these considerations, however, it is to be observed that *Atax* (F.) Dugès, is invalid as none of the species originally included in the genus were included by Dugès in the restricted genus.

Since *Atax* F. is invalid, it cannot be longer retained as a generic name. As pointed out by Oudemans and by Wolcott, there is no choice but to give to the genus to which C. L. Koch, and later Bruzelius, gave the definition it now bears, the name of *Unionicola* Hald., and the generic name of our British species must be changed accordingly.

Wolcott selected from Haldeman's species *U. oviformis* as typical, and as it appears to be the species named *Hydrachna ypsilophora* by Bonz, the type of the genus, as designated by Wolcott, is *Unionicola ypsilophora* (Bonz).

XXIII. *A Method for the Study of the Animal Ecology of the Shore.* By L. A. L. King, M.A., and E. S. Russell, M.A.

(Read 25th January 1909; received same date.)

I. Introduction.

Animal Ecology we take to mean the study of the relations between animals and their environment both animate and inanimate. We are concerned here with these relations as exhibited by the animals of the shore, meaning the region between extreme tide-marks. The most important work on this subject with which we are acquainted is found in the series of "Cold Spring Harbor Monographs," published by the Brooklyn Institute of Arts and Sciences. These are Monographs of single species containing a detailed account of their habits and environmental relations. Here we must not omit to mention also the interesting sketch of the general Ecology of the Cold Spring Sand Spit, which is given by C. B. Davenport in the Decennial Publications of the University of Chicago, 1903.

Apart from these the study of shore animals has been, up to the present, mainly a series of isolated observations of facts, in themselves of much interest, but tending only occasionally to throw light upon the problems of Ecology. Faunistic lists have been compiled, and the habits of some animals have been studied with care, but scarcely any attempt has been made to study in a systematic and comprehensive manner the actual conditions of life on the shore.

The first essential is to observe the relations which actually exist between the animals present and their environment, in other words, to make a complete survey of the shore.

This can be done by examining each particular kind of shore in turn. There are for instance sandy shores, muddy shores, pebbly shores, rocky shores. It is well known that each of these has its characteristic fauna. One primary investigation in shore Ecology would be the study

of such typical faunas and the correlation of the differences they exhibit with the peculiarities of the environment of each. It would be found that the fauna of each distinct region consisted of a typical constellation of species, such species being present as were adapted to the particular conditions. Burrowing animals are found on sandy and muddy shores, sedentary animals on fixed rocks and stones, and so on. But it might also be found that certain species were common to two or more of these regions, but that they appeared to have undergone typical modification. We might distinguish then, *Association differences,* or local differences in the grouping of species, from *Modification differences*, or local differences in individuals of a species. To appreciate these differences it would be necessary to make an intensive study of a sample of each type of shore. Suppose we consider then a definite area on the shore belonging to one of these distinct kinds of shore. It is clear that even within such an area we shall find local variations in the fauna. A very slight acquaintance with shore life is sufficient to show one that the fauna at or near low-water mark is not only richer than, but different in character and composition from the fauna at higher levels. For convenience of study and to make our observations systematic, it will be necessary to divide up the beach into *Zones* according to depth.

Another circumstance which we can reasonably suppose to have considerable influence upon the character of the shore fauna is the occurrence of fresh-water streams flowing down the beach. It will be necessary, then, to mark off the area traversed by the fresh water, and compare its inhabitants with those of the neighbouring parts of the shore.

It is a fact known to all workers who have had experience in shore collecting, that many animals are to be found habitually in certain positions on the shore, lurking under stones, attached to the under surface of loose boulders, adhering to weed, and so on. It will be necessary, then, to distinguish *Positions* of various kinds and compare the typical faunas of these. It seems to us that only by going into details of this kind do we get into touch with the real

complexity of environmental relations. In each subdivision of the beach—zones, fresh-water areas, and positions, we must study (1) the correlation of the structure and behaviour of its inhabitants with the physical peculiarities of the division, and (2) the interrelations existing between the species found in it.

But there are certain *fluctuating* environmental conditions which will affect the beach as a whole, and be felt by all its inhabitants. We must make allowance in our scheme for the study of their effects.

The chief of these changing conditions is undoubtedly the state of the tide. What we might call the statical relations of shore animals to depth are best considered by dividing up the beach into zones, as we have already proposed to do; but it is evident that the activities of the inhabitants in each zone are largely influenced by the state of the tide. The tide makes all the difference for some species between activity and quiescence or even latent life. For instance, many species take shelter in holes and corners when the tide is out, and travel freely when covered ; *Littorina rudis* is often found quite above ordinary high-water mark, and according to Bohn's observations[1] it subsists in a state of suspended animation from one spring tide to another. It will be necessary then to note the state of the tide when collecting from the various positions.

It might also be well to study the variations associated with the alternation of night and day. Another influence which seems to have a certain effect upon the intimate distribution and the activities of shore animals is the degree of humidity of the air, especially when this affects in a marked degree the surface of the stones and weeds, making them moist or dry. For instance, we have observed that *Littorina rudis*, on the higher part of the beach, comes out on the tops of stones in greater numbers in damp weather than in dry. Along with this the other weather conditions should be considered — of rain, sunshine, temperature, barometric pressure, and direction and force of the wind. The effect of storms upon the shore fauna is often quite

[1] C.R. Acad. Sci., cxxxix. (1904), pp. 610, 611.

marked, and is therefore worthy of special consideration. If the observations were continued long enough, we should no doubt recognise seasonal variations in the fauna. It would be necessary to analyse the causes of such variations and correlate them if possible with variations in temperature, atmospheric conditions, salinity, and food-supply, as well as with breeding habits, normal life-cycle, etc. Slow secular changes might be revealed by observations extending over many years.

How are our observations to be directed to these ends? We must start with a careful study of the physical characters of our chosen area, its extent, aspect, shelter, slope, the nature of the ground, the tidal currents, the salinity of the water, and so forth. We must then divide up the beach into zones, determine the area exposed to the action of fresh water, and classify the "positions" to be recognised.

We must make systematic collections representative of the complete fauna, on many different occasions during the year, noting on each occasion the conditions of weather and tide. In making such collections, special attention must be directed to the state of maturity the proportion of mature and immature individuals, and the extent of the breeding season, in order to gain as full a knowledge as possible of life-histories.

In order to test the actual working of the method outlined here, we made, last August, a systematic series of observations extending over a period of three weeks. We selected for the purpose a small bay, which was within easy reach of the Marine Biological Station at Millport. Here we made collections and observations daily. From the data obtained in this short period, and from the study of a single area of very limited extent, we do not attempt to draw conclusions of general ecological significance. We have investigated methods rather than zoological facts.

We proceed to describe the area chosen, and the methods adopted for collecting and recording.

It may be mentioned, in passing, that this area was not a rich one from the collector's point of view.

II. Description of the Experiment.

The Area Chosen was a small bay on the east side of Cumbrae facing Fairlie, and lying in the sheltered channel between the island and the mainland, protected from the prevailing winds both from the south-west and from the east. The aspect was, roughly, east by south-east.

Extent of the Bay.—At its landward limit, *i.e.*, where bounded by a grass-covered bank, the breadth was 50 feet. At low-water mark, ordinary tides, the breadth was about 100 feet. The shore sloped gradually from the upper to the lower limit indicated, the fall being roughly 1 in 7·5. The distance from high-water mark to low-water mark was 80 feet.

Nature of the Shore.—At its north and south limits, the bay was bounded by rocks, red sandstone of Carboniferous age.

The shore was covered by shelly sand and gravel, overlying rock similar to that of the boundaries and found at a depth of a few inches to a foot below the surface. This surface was covered, over almost the whole area, by loose stones, varying in size from 9 to 18 inches in diameter, flattened, and having a rough surface; occasional boulders occurred of larger size.

At the southern corner of the top part of the area a stream of fresh water could be traced by the presence of a growth of green weed, *Enteromorpha intestinalis*, spreading out in triangular form from above high-water mark. The fresh water, percolating through the gravel, was found to pass down in a straight course from its entrance, spreading out as it passed on towards low water, but diverted from the southern portion of the bay, in its lower part, by projection of the bounding rocks, at a distance of 24 to 28 feet from high-water mark.

Zones.—The zoning was according to depth. The nature of the seaweeds was taken as a rough guide for the delimitation of the zones, and the following were distinguished: Zone 1, extending 24 feet downwards, characterised by the occurrence of *Fucus platycarpus* and *Pelvetia canaliculata*;

Zone 2, extending 30 feet down from the lower limit of Zone 1, and characterised by the great abundance of *Ascopyhllum nodosum;* Zone 3, extending downwards another 26 feet, with the characteristic weeds *Fucus vesiculosus* and *Fucus serratus;* and Zone 4, which included as much of the generally recognised "Laminarian Zone" as was exposed at ordinary low tides. In addition a Drift Zone was recognised, extending from the lower limit of the grass to the upper limit of Zone 1.

Description of the Zones.—The drift, consisting of masses of *Fucus vesiculosus, Fucus serratus, Ascophyllum, Zostera, Polysiphonia,* etc., extended 15 feet downwards.

Zone 1 extended 24 feet downwards, upper limit 49½ feet wide, lower limit 54½ feet wide, this limit being marked by a transverse ridge of rock in the centre.

The stones in the upper 16 feet of this zone ("Zone 1, Upper") were almost bare of weed, the lower limit of this weedless area being a line between two rocks, which we called the Pelvetia Rocks.

In the lower 8 feet of this zone ("Zone 1, Lower"), the stones were mostly covered with *Pelvetia canaliculata* and *Fucus platycarpus.* The depth of water at ordinary high tide was 2¼ feet at the lower limit of Zone 1.

Zone 2 was marked at its lower limit by two conspicuous rocks covered with *Ascophyllum nodosum.* The distance between these was 96 feet, and the extent downwards of the zone was 30 feet. The stones here were not so flat as in Zone 1, and scattered boulders of larger size were present 2 or 3 feet in longer diameter. The depth of water at ordinary high tide was 6¾ feet at the lower limit of Zone 2.

Zone 2 was characterised by *Ascophyllum nodosum,* which showed a marked boundary at the upper limit, but extended, in scattered tufts, to a considerable distance below the lower limit.

For convenience of collecting we divided this zone into upper and lower halves, each 15 feet in downward extent.

Zone 3 extended down 26 feet to the commencement of the *Laminaria.*

Fucus serratus was here dominant, especially in the lower half of the zone.

The depth at the lower limit of Zone 3 was about 10 feet. Our Zone 4 was only 6 feet in extent from Zone 3 to low-water mark. It was thickly overgrown with *Laminaria*.

Positions.—The following positions were recognised:—

1. Upper surface of stones.
2. Beneath stones not imbedded.
3. In substratum,[1] and reached by digging.
4. On or amongst different kinds of weed.

E.g., in Zone 1.	*Fucus platycarpus.*
,,	*Pelvetia canaliculata.*
,,	*Enteromorpha intestinalis.*
Zone 2.	*Ascophyllum nodosum*,[2] Base.
,,	*Ascophyllum nodosum*, Branches.
,,	*Fucus platycarpus.*
Zone 3.	*Fucus serratus.*
,,	*Chondrus crispus.*
,,	*Cladophora rupestris.*
Zone 4.	*Laminaria*, Branches.
,,	*Laminaria*, Base.
,,	*Fucus serratus.*
,,	*Chondrus crispus.*
,,	*Cladophora rupestris.*
Drift (f.w.).	*Enteromorpha intestinalis.*

Fresh-Water Area.—In every zone except Zone 4 an area over which fresh water trickled could be recognised. These zones were therefore divided up into a fresh-water portion, and a portion not exposed to action of fresh water at low tide. Zone 1, lower, was throughout its extent exposed to fresh water, owing to the presence of a small stream at the northern corner of the bay. In fact the fresh water percolated all over the bay with the exception of an area (in Zones 2 and 3) in the southern part of the bay, from

[1] This position can be subdivided according to the nature of the substratum, *e.g.*, shell gravel, sand, mud, etc.

[2] It has been necessary to distinguish as separate positions, *base*, and *branches*, since each has a typical fauna.

which it was cut off by a promontory of rock. Naturally, only the two positions, "under stones," and "in substratum," are affected by the percolation of fresh water, when the tide is out, and in our experiment we studied the distribution of the fauna only under low-tide conditions.

Description of a Collecting Excursion or "Haul."—The following data were invariably recorded before commencing work :—

Date.
Time.
Weather conditions.
Temperature of air and water.
Condition of humidity as shown by state of rock surface.
Wind.
Barometer
State of tide.
Collections were then made from definite positions in definite zones or subzones, and conspicuous features of the distribution of abundant species were noted on the spot.

Recording.—The usual method was to record on the spot all forms readily identified at sight, with notes on their relative abundance, and on any other points of general ecological interest, *e.g.*, feeding habits, activity, and general behaviour, then to take carefully-labelled living samples of all material requiring fuller investigation. Such investigation might involve washing of weeds, decanting of sand and mud, and the microscopic investigation of surface fauna of movable stones.

This material was taken to the Marine Station and worked up as soon as possible—a very important point, for many species are not readily preserved in a state in which they can be identified with certainty (*e.g.*, Protozoa, Hydroids, Actiniæ, Turbellaria, Nemertines, Compound Ascidians, etc.).

Species not identified at once were carefully fixed and transferred to suitable preserving fluids, a label being enclosed with each sample. The same procedure was

adopted in the case of samples containing a number of organisms which required for their separate identification a greater time than we had at our disposal.

It will be evident that this method does not involve wholesale removal of animals from the "Station" under investigation, with consequent disturbance of the balance of life.

The details of each "Haul" were at once entered in a journal. A Roman numeral being assigned to the Haul, and a (Greek) letter to the "Position" from which specimens were taken. Thus any sample preserved was labelled with a numeral and a letter, giving ready reference to full details recorded in the journal. In illustration of the practical details of the work, we introduce here a page from our journal. It would be useless to transcribe the journal in its entirety, since the observations formed only a single series, and gave us, through their short duration, no opportunity of discovering variations in the fauna in relation to changes in temperature, weather, etc.

HAUL V.

Date 7/8/08.	
Time, ...	11.10. A.M.
Weather, ...	Bright, sunny.
Wind, ...	N.W., cold.
Air temperature, . . .	Sun, 21·5° C. Shade 18·5° C.
Sea, „	16° C.
Barometer, ...	768·5 mm.
State of tide, . . .	Ebbing, halfway down Zone 3.
Humidity, ...	Rocks dry on surface.

Collections made.

Zone 2. Upper.	Upper surface of stones—α
Zone 2. Lower.	Upper surface of stones—γ
	Under surface of stones in fresh water area—δ
	Under surface of stones outside fresh water area—ϵ

Tabulation of Results.—The lists of species were entered on separate sheets, each bearing the number of the Haul, the Zone, and the Position.

III. List of Species Obtained.

We give here the complete list of the species, compiled from our separate sheets.

To facilitate the drawing of conclusions from our records, we constructed Tables which showed at a glance the distribution of the various species in Zones, Positions, fresh-water areas, and areas without fresh water. We give here, p. 247, a sample of these Tables, in order to show the method of their construction. Several of the Positions have been omitted in order to save space.

List of Species Classified according to Zones and Positions.

DRIFT, UPPER.

A. Without fresh water.

Orchestia gammarellus (Pall.).
Porcellio scaber, Latr.
Isotoma maritima, Tullb. } Collembola.
Xenylla humicola (O. Fabr.). Abundant. } Collembola.
Cercyon depressus, Steph.
,, *littoralis*, Gyll. Abundant. } Coleoptera.
Homalium laeviusculum, Gyll. } Coleoptera.
Two spp. of Dipteron puparia.

DRIFT, LOWER.

A. Without fresh water.

Various Nematodes.
Various Enchytræids.
Orchestia gammarellus (Pall.).
Molgus (*Bdella*) *littoralis* (L.). Very abundant.
Cercyon littoralis, Gyll.
Homalium riparium, Thoms.
Limosina zosteræ, Hal. Abundant. (Dipteron).

B. With fresh water.[1]

i. On Enteromorpha intestinalis.

Psammoryctes sp. Young (Oligochæt).
Chironomus spp.

ZONE 1—UPPER HALF.

A. Without fresh water.

i. Upper Surface of Stones.

Littorina obtusata (L.). Very few.
,, *rudis* (Maton). Very few.
Molgus (Bdella) littoralis (L.).
Limosina zosterae, Hal.

B. Where fresh water percolates.

i. Under Stones.

Actinia equina, L.
Procerodes (Gunda) ulvæ[2] (Oersted), and cocoons (Turbellarian).
Psammoryctes costatus (Clap.).[3]
Enchytræidæ.
Spirorbis borealis, Daudin.
Littorina rudis (Maton). Very common; lying deep.
Balanus balanoides (L.). Scarce.
Gammarus locusta (L.).
Jæra albifrons, Leach.
Ligia oceanica (L.). Young individuals; common; one adult, dead.
Halacarus sp.

ii. On Enteromorpha intestinalis.

Procerodes ulvæ (Oersted).
Psammoryctes sp. Immature.
Enchytræids. Various.
Spirorbis borealis, Daudin. Dead shell.

[1] Specimens of *Gammarus locusta* (L.), were taken here on 28th November 1908, swimming in perfectly fresh water.

[2] See Böhmig, L., *Zeitschr. f. Wiss. Zool.*, lxxxi. (1906), p. 348, "Tricladen Studien I." The above species has been previously recorded, for the Clyde, by L. von Graff.

[3] See W. B. Benham, *Quart. Journ. Micr. Sci.*, xxxiii. (1892), pp. 187-218, with plates v.-vii.

Gammarus locusta (L.). Young.
Jæra albifrons, Leach.
Orthocladius (*variabilis*?, Staeg).
Orthocladius sp.
Spilogaster maculosa, Meig. Puparium.

iii. In Substratum (Shingle).

Procerodes ulvæ (Oersted).
Enchytræidæ.
Helcion pellucidum (L.). A dead shell.
Gibbula cineraria (L.). A dead shell.
Littorina rudis (Maton). Dead shells.
Lacuna divaricata (Fabr.). A dead shell.
Gammarus locusta (L.).

ZONE 1—LOWER HALF.

i. Upper Surface of Stones.

Littorina rudis (Maton). Not numerous.
Balanus balanoides (L.). 50 per cent. dead.
Molgus littoralis (L.).

ii. Under Surface of Stones.

Procerodes ulvæ (Oersted).
Littorina rudis (Maton). Very abundant.
Balanus balanoides (L.). Small; very abundant.
Jæra albifrons, Leach. Abundant; mostly females.
Ligia oceanica (L.). Not so abundant.

iii. On Fucus platycarpus.

Various Nematodes.
Rhabdocœle. 1·5 mm.
Littorina rudis (Maton). 1 mm.; common.
,, *obtusata* (L.). A few.
Hyale nilssoni (Rathke).
Gammarus marinus, Leach.
Jæra albifrons, Leach.
Ligia oceanica (L.). Young.
Idotea granulosa, Rathke. Up to 1 cm.

iv. On Pelvetia canaliculata.

Littorina rudis (Maton). 1 mm.; common.
Hyale nilssoni (Rathke).

Gammarus marinus, Leach. Young.
Ligia oceanica (L.). Young.

ZONE 2—UPPER HALF.

A. Where fresh water does not percolate.

i. Upper Surface of Stones.

Actinia equina, L. Common.
Sagartia troglodytes, Johnst. Small; in crevices.
Enchytræids. Various.
Modiola modiolus, L. 3 mm.
Mytilus edulis, L. Young; in crevice.
Patella vulgata, L. One 3 cm.; travelling.
Purpura lapillus (L.). Full grown, and minute.
Littorina rudis (Maton). ·5 mm and less; very common.
,, *obtusata* (L.). Full size, and minute.
,, *littorea* (L.). Large (28 mm.); in moist situations.
Balanus balanoides (L.). Very common.
Gammarus marinus, Leach. Very common.
Ligia oceanica (L.). Young.
Carcinus mœnas (Penn.). 4 mm. and 17 mm.
Anurida maritima (Guer.).
Staphylinidæ and larvæ.
A black Ant was observed, but not captured.

ii. Under Stones.

Actinia equina, L.
Procerodes ulvæ (Oersted), with cocoons.
Spirorbis borealis, Daudin.
Alcyonidium mytili, Daly.
Patella vulgata, L.
Purpura lapillus (L.).
Littorina rudis (Maton).
,, *littorea* (L.).
Balanus balanoides (L.).
Jæra albifrons, Leach.
Idotea granulosa, Rathke.
Carcinus mœnas (Penn.).

iii. On Base of Ascophyllum nodosum.

Mytilus edulis, L.
Balanus balanoides (L.).

iv. On Branches of Ascophyllum.

Littorina obtusata (L.). Few.
Hyale nilssoni (Rathke).
Gammarus marinus, Leach.
Jæra albifrons, Leach.
Idotea granulosa Rathke.

v. On Fucus platycarpus.

Littorina rudis (Maton). Few.
,, *obtusata* (L.). Few.
Hyale nilssoni (Rathke).
Gammarus marinus, Leach.
Jæra albifrons, Leach.
Idotea granulosa, Rathke.

ZONE 2—UPPER HALF.

B. Where fresh water percolates.

i. Under Stones.

Actinia equina, L.
Sagartia troglodytes, Johnst. Young.
Procerodes ulvæ (Oersted), and Cocoons of this species.
Enchytræids.
Mytilus edulis, L. 1 inch and smaller; very abundant.
Littorina rudis (Maton).
,, *littorea* (L.). Full-sized, and young.
Purpura lapillus (L.).
Various Ostracods.
Balanus balanoides (L.).
Gammarus marinus, Leach.
Jæra albifrons, Leach. Adults and young; very abundant.
Idotea granulosa, Rathke.
Carcinus mænas (Penn.). 50 mm., and smaller.
Dipteron larvæ.

ii. In Substratum (Shell Gravel).

Polystomella crispa, L. Empty tests; fairly abundant.
Cocoons of *Procerodes ulvæ*.
Psammoryctes costatus (Clap.).
Enchytræidæ.
Mytilus edulis, L. Half-grown.

Gammarus marinus, Leach.

Mytilus edulis, L. Half-grown.	Dead Shells.
Patella vulgata, L.	
Gibbula cineraria (L.).	
Purpura lapillus (L.).	
Littorina rudis (Maton).	
,, *obtusata* (L.).	
,, *littorea* (L.).	

ZONE 2—LOWER HALF.

A. Where fresh water does not percolate.

i. Upper Surface of Stones.

Actinia equina, L.
Patella vulgata, L.
Purpura lapillus (L.). Commoner than in Upper half of Zone.
Littorina rudis (Maton).
,, *littorea* (L.). Commoner than in Upper half.
Balanus balanoides (L.).

ii. Under Stones.

Leucosolenia botryoides (Ellis & Sol.).
Halichondria panicea (Pall.).
Sertularia pumila, L.
Actinia equina, L.
Various Nematodes.
Lineus gesserensis, O.F.M. Common; in clusters.
Psammoryctes benedeni (Udek.).
(= *Hemitubifex ater*, Beddard).
Cirratulus cirratus (Müll.). Small; common; in clusters.
Spirorbis borealis, Daudin. Abundant.
Theodisca mammillata, Clap. (Polychaet).
Cribrilina punctata (Hassall).
Schizoporella unicornis (Johnst.). Over-growing Halichondria at one part.
Lepralia pallasiana (Moll.).
Alcyonidium mytili, Daly.
Modiolaria discors (L.). 2 mm.
Anomia ephippium, L.
Chiton marginatus, Jeff.
Patella vulgata, L.
Purpura lapillus, (L.), and its egg-capsules.

Littorina rudis (Maton).
,, *obtusata* (L.).
Lacuna divaricata (L.). Young; in clusters.
Rissoa striata (J. Ad.).
A few Copepods.
Verruca stromia (O.F.M.).
Jæra albifrons, Leach.
Idotea granulosa, Rathke.
Pycnogonum littorale, Ström. A few. ⎫
Phoxichilidium femoratum (Rathke). ⎬ Pycnogonida.
Anoplodactylus pygmaeus (Hodge). ♂ ⎭
Dipteron larva.

iii. On Base of Ascophyllum nodosum.

Coryne pusilla, Gærtner.
Balanus balanoides (L.).

iv. On Branches of Ascophyllum nodosum.

Procerodes ulvæ (Oersted). One; small.
Various Nematodes.
Littorina obtusata (L.). Small, and egg-masses.
Various Ostracods.
Thalestris clausii, Norm., and other Copepods.
Gammarus marinus, Leach.
Hyale nilssoni (Rathke).
Idotea granulosa, Rathke. Very abundant.
Jæra albifrons, Leach. A few.

v. On Fucus platycarpus.

Littorina obtusata (L.).
Various Copepods.
Idotea granulosa, Rathke.
Jæra albifrons, Leach.
Hyale nilssoni (Rathke).
Gammarus marinus, Leach.
Dipteron larvæ.

ZONE 2—LOWER HALF.

B. Where fresh water percolates.

i. Under Stones.

Coryne pusilla, Gærtner.
Actinia equina, L.

Procerodes ulvæ (Oersted). Numerous ; cocoons numerous.
Alcyonidium mytili, Daly.
Mytilus edulis, L. 10 to 20 mm. long.
Purpura lapillus (L.).
Littorina rudis (Maton).
,, *littorea* (L.).
Balanus balanoides (L.).
Idotea granulosa, Rathke.
Carcinus mænas (Penn.). 30 mm.

ZONE 3.

A. Where fresh water does not occur.

i. Upper Surface of Stones.

Sycon compressum, auctt. 1 cm.
Halichondria panicea (Pallas).
,, *incerta*, Bowerbank.
Clava multicornis, Forskål. Very small, not more than 1·5 mm.
Campanularia flexuosa, Hincks.
Sertularia pumila, L.
Actinia equina, L.
Sagartia troglodytes, Johnst. In crevices of smooth rock.
Rhabdocœls. A few.
Spirorbis borealis, Daudin.
Anomia ephippium, L.
Patella vulgata, L. Adult ; and 3 mm.[1]
Acmæa testudinalis (Müll.).
Gibbula cineraria (L.).
,, *umbilicata* (Mont.).
Purpura lapillus (L.), and egg capsules.
Littorina littorea (L.). Travelling.
,, *obtusata* (L.). Travelling ; more active than the others.
,, *rudis* (Maton).
Lacuna divaricata (Fabr.).
Archidoris tuberculata (Cuv.). 6 cm.
Balanus balanoides, L.
,, *crenatus*, ? Brug. Basal plate only.
Verruca stromia (O.F.M.).
Various Ostracods.

[1] A few of some ova which were artificially fertilised gave segmentation stages.

Carcinus mœnas (Penn.) Young.
Phoxichilidium femoratum (Rathke). ♀ adult, and ♀ young.
Halacarus (*balticus*? Lohm.).

ii. Under Stones.

Rotalina sp.
Textularia sp.
Leucosolenia botryoides (Ell. & Sol.).
Sycon compressum, auctt.
,, *coronatum*, Ell. & Sol.
Leuconia nivea, Grant.
Halichondria panicea (Pall.).
Dysidea fragilis, Johnst.
Halisarca dujardini, Johnst.
Coryne sp.
Campanularia flexuosa (Hincks).
Sertularia pumila, L.
Actinia equina, L.
Urticina felina (L.).
Procerodes ulvæ (Oersted).
Various Nematodes.
Chætosoma tristicochæta (Panceri). One.
Lineus gesserensis, O.F.M. Small; 3 to 4 mm.
Tetrastemma candida (O.F.M.). Reddish-orange variety; 1·5 cm.
Nereis pelagica (L.).
Cirratulus cirratus (Müll.).
Spirorbis borealis, Daudin. Also embedded in *Botrylloides* sp.
Pomatoceros triqueter, Mörch.
Amphicora fabricii (Müll.). Abundant.
Membranipora lineata (L.).
Cribrilina punctata (Hassall).
Schizoporella unicornis (Johnst.). Common.
Lepralia pallasiana (Moll.).
Alcyonidium mytili, Daly.
Amphiura sp.
Anomia ephippium, L.
Modiolaria discors (L.).
Saxicava rugosa var. *arctica* (L.).
Acmæa testudinalis (Müll.). 1 mm., and adult.
Patella vulgata (L.).
Gibbula cineraria (L.).
,, *umbilicata* (Mont.).

Purpura lapillus (L.). Adult; also young.
Littorina littorea (L.). 1 mm.; abundant; and capsules.
Lacuna divaricata (Fabr.).
Rissoa striata (J. Ad.).
Copepoda. Abundant.
Ostracoda. Abundant.
Balanus crenatus, Brug.
Verruca stromia (O. F. M.).
Amphithoë rubricata (Mont.), and young.
Jæra albifrons, Leach.
Gammarus marinus, Leach.
Hyale nilssoni, Rathke.
Carcinus mænas (Penn.). Post-megalopa, and older.
Pycnogonum littorale (Ström.).
Phoxichilidium femoratum (Rathke). Fairly common; occurring in association with fragments of weed, *Furcellaria furcata*, which it resembles.
Anoplodactylus pygmæus (Hodge).
Gamasus sp.
Halacarus sp.
Dipteron larvæ.
Botrylloides sp.

iii. On Cladophora rupestris.

Leucosolenia botryoides (Ell. and Sol.).
Actinia equina, L. Small.
Procerodes ulvæ (Oersted).
Amphicora fabricii (Müll.). Tubicolous worm.
Skenea planorbis (Fabr.).
Bowerbankia imbricata (Adams).
Various Copepoda and Ostracoda.
Amphithoë rubricata (Mont.).
Acarina.

iv. On Chondrus crispus.

Coryne pusilla, Gærtner.
Doto coronata (Gmel.). On the Coryne.

v. On Fucus serratus.

Lepralia pallasiana (Moll.).
Alcyonidium hirsutum (Flem.).

ZONE 3.

B. Where fresh water percolates.

i. In Substratum.

Procerodes ulvæ (Oersted).
Psammoryctes costatus (Clap.).
Gammarus marinus, Leach.
Jœra albifrons, Leach.
Dead Shells, Tests, etc.—
Polystomella crispa, L. In the sandy clay; fairly abundant, well preserved.
Rotalia sp.
Spirorbis sp.
Echinus esculentus (L.). Fragment of test and spines.
Mytilus edulis, L.
Mactra subtruncata (da C.).
Patella vulgata, L. Many small; 15 to 25 mm.
Gibbula cineraria (L.).
Purpura lapillus (L.).
Littorina littorea (L.).
,, *rudis* (Maton).
,, *obtusata* (L.).
Lacuna divaricata (Fabr.).
Tests of Ostracods.
Balanus balanoides (L.).
Carcinus mœnas (Penn.). Remains.

ZONE 4.

Note.—Only one haul (Haul IV.) was taken in this zone. The records are therefore not representative of the complete fauna.

i. Upper Surface of Stones.

Folliculina ampulla (Müll.). A loricate Infusorian[1] on *Spirorbis borealis.*
Folliculina elegans (Clap. and Lach.), on *Balanus crenatus.*
Halichondria panicea (Pall.).
Tubularia simplex, Alder.
Clytia johnstoni (Alder).

[1] Savile Kent, *Manual of Infusoria*, pl. xxix. fig. 40.

Sertularia pumila, L.
Actinia equina, L. Young.
Leptoplana tremellaris, O.F.M.
Rhabdocœl.
Nereis pelagica, L.
Harmothoë imbricata, L.
Phyllodocid.
Lagisca floccosa, Sav.
Spirorbis borealis, Daudin.
Pomatoceros triqueter, Mörch.
Amphicora fabricii (Müll.).
Acmæa virginea (Müll).
Calliostoma zizyphinus (L.). 3 mm.
Phasianella pulla (L.). Young; 1 to 2 mm.; fairly abundant in washings.
Egg Capsules of *Purpura lapillus* (L.).
Rissoa striata (J. Ad.).
Various Ostracods.
Balanus crenatus, Brug.
Verruca stromia (O. F. M.).
Amphithoë rubricata (Mont.).
Phoxichilidium femoratum, Rathke.
Botrylloides violaceus, M. Edw.

ii. On Laminæ of Laminaria Digitata.

Membranipora membranacea (L.). Also found on the stalks of Lam. dig.
Spirorbis borealis, Daudin.
Helcion pellucidum (L.).
Gibbula cineraria (L.). Abundant.
„ *umbilicata* (Mont.). Less abundant.
Littorina obtusata (L.). Yellow, brown, and striped; abundant.

iii. On Base of Laminaria Digitata.

Leucosolenia botryoides (Ell. and Sol.).
Halichondria panicea (Pall.).
Dysidea fragilis, Johnst.
Halisarca dujardini, Johnst.
Clytia johnstoni (Alder).
Sertularia pumila, L.
Actinia equina, L.

Nereis pelagica, L. Abundant.
Eulalia sp.
Harmothoë imbricata, L.
Amphitrite johnstoni (Malmgren).
Spirorbis borealis, Daudin. Very small.
Membranipora membranacea (L.).
Anomia ephippium, L.
Mytilus edulis, L. 6 to 10 mm.
Modiola modiolus, L. 5 mm.
Saxicava rugosa var. *arctica* (L.). 7 to 9 mm.
Helcion pellucidum (L.).
Gibbula cineraria (L.).
Egg Capsules of *Purpura lapillus* (L.).
Rissoa striata (J. Ad.).
Amphithoë rubricata (Mont.), and young in nest; fairly common.
Botrylloides violaceus, M. Edw.

iv. On Fucus serratus.

Clytia johnstoni (Alder). } On the weed, and on the encrusting
Sertularia pumila (L.). } Polyzoa.
Spirorbis borealis, Daudin.
Membranipora membranacea (L.).
" *pilosa* (L.).
Alcyonidium hirsutum (Flem.).
" *mytili*, Daly. Thinner and flatter than on stone.
Flustrella hispida (Fabr.).

v. On Cladophora Rupestris.

Bowerbankia imbricata (Adams).

vi. On Chondrus Crispus.

Alcyonidium gelatinosum (L.).

Sample of Table of Distributions.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	ZONES.										POSITIONS.				
NAME.	Drift Upper.	Drift Lower.	Zone 1, Upper.	Zone 1, Lower.	Zone 2, Upper.	Zone 2, Lower.	Zone 3.	Zone 4.	Non-Fresh Water.	Fresh Water.	Upper Surface of Stones.	Under Stones.	In sub-stratum	On Clado-phora.	On base of Lam-inaria.
PROTOZOA.															
Textularia sp.,							×		×			×			
Polystomella crispa,					D†		D			D			D		
Rotalina,							×		×	D		×	D		
**Folliculina ampulla*,								×	×		×				
* ,, *elegans*,								×	×		×				
PORIFERA.															
Leucosolenia botryoides,						×	×	×	×			×		×	×
Sycon coronatum,							×		×			×			
,, *compressum*,							×		×		×	×			
Leuconia nivea,							×		×			×			
Halichondria panicea,						×	×	×	×		×	×			×
,, *incerta*,							×		×		×				
Dysidea fragilis,							×	×	×			×			×
Halisarca dujardini,							×	×	×			×			×

* See List, Zone 4.

† D stands for dead.

Remarks on the Foregoing Lists.

1. *Relation to Fresh Water.*

The following are the only species which were found to occur in the living state where bathed by fresh water. The upper limit of their occurrence is indicated in brackets after each.

Coryne pusilla	(Zone 2, Lower).
Actinia equina	(Zone 1, Upper).
Sagartia troglodytes	(Zone 2, Upper).
Procerodes ulvæ	(Zone 1, Upper).
Psammoryctes costatus	(Zone 1, Upper).
Psammoryctes sp.	(Drift, Lower).
Enchytræids, various	(Drift, Lower).
Spirorbis borealis	(Zone 1, Upper).
Alcyonidium mytili	(Zone 2, Upper).
Purpura lapillus	(Zone 2, Upper).
Littorina rudis	(Zone 1, Upper).
Littorina littorea	(Zone 2, Upper).
Balanus balanoides	(Zone 1, Upper).
Gammarus marinus	(Zone 1, Lower).
Gammarus locusta	(Zone 1, Upper).
Idotea granulosa	(Zone 1, Lower).
Jæra albifrons	(Zone 1, Upper).
Ligia oceanica (juv.)	(Zone 1, Upper).
Carcinus mœnas	(Zone 2, Upper).

It is noteworthy that all the above species occur as high up on the shore as Zone 2, Upper, and that some occur as high as Zone 1, Upper. The only other forms (exclusive of the semi-terrestrial Drift Fauna) which were found above Zone 3, were Rhabdocœls, *Patella vulgata, Modiola modiolus, Littorina obtusata, Hyale nilssoni.* These were not recorded from fresh water. Of them *Littorina obtusata* is almost invariably found on weed, whilst *Hyale nilssoni* we have taken only amongst weed. Further investigation may reveal the presence of Rhabdocœls and of Limpets in fresh water conditions. The conclusion seems warranted that species which live high up on the shore possess considerable power of resisting unfavourable conditions, as is

shown by their occurrence in positions where they are exposed to fresh water. It is probably to this power that they owe their ability to occupy the higher reaches of the shore.

2. *Notes on the Species.*

PROTOZOA.—The scarcity of Foraminifera was remarkable. Possibly it may be explained by the abundance of fresh water in the area.

PORIFERA.—None of the species were found in situations exposed to fresh water. Only two species, viz., *Leucosolenia botryoides* and *Halichondria panicea,* were found as far up as Zone 2, Lower. The base of *Laminaria* appears to be a favourite position for several species.

HYDROZOA.—The distribution in depth is similar to that of the Sponges, but they occur in more exposed positions, *e.g.*, on the upper surface of stones, and on the fronds of *Ascophyllum* and *Fucus serratus.* Only one species was found in fresh water, viz., *Coryne pusilla. Clava multicornis* is found only on the under surface of stones. *Tubularia simplex* and *Clytia johnstoni* here appear to be confined to Zone 4. They are well known to occur at greater depths in the Laminarian region, and are not purely shore forms.

ACTINOZOA.—The chief feature of note is the ubiquity of *Actinia equina.*

Urticina felina does not seem to occur above Zone 3.

TURBELLARIA.—*Procerodes ulvæ,* like *Actinia equina* is ubiquitous. It occurs all over the shore, but is commonest where a stream of fresh water flows over the beach. In such a stream it may be found in great abundance right up to high-water mark, where it stops absolutely. This is rather remarkable, for experiment has shown us that it can endure immersion in fresh water for at least two days.

Leptoplana tremellaris, found in Zone 4, is not strictly an animal of the shore.

OLIGOCHÆTA.—These, as we should expect, are found principally in the Drift and on the upper reaches of the shore.

Psammoryctes costatus, however, occurs as far down as Zone 3.

POLYCHÆTA.—They seem to be very sensitive to fresh water, for only one of them, *Spirorbis borealis,* occurs in a position exposed to fresh water. Perhaps the operculum enables *Spirorbis* to resist the deleterious effect of fresh water. Most of them occur in Zones 3 and 4. Polychæts are among the most characteristic inhabitants of Zone 4.

POLYZOA.—While the majority of the forms occur in the lower reaches and avoid contact with fresh water, *Alcyonidium mytili,* as has been mentioned above, occurs both high up and in fresh water. *Fucus serratus* seems to be a favourite position for Polyzoa. *Bowerbankia imbricata* we have found only upon *Cladophora.* The favourite position occupied by *Membranipora membranacea* is of course the laminæ and stem of *Laminaria,* but it is found also on *F. serratus.*

PELECYPODA.—*Modiolaria discors* is found typically in a little nest made of byssus threads on the under surface of stones.

Mytilus edulis, we have noticed, is most abundant in Zone 2, Upper. Minute specimens were frequently found sheltering in empty barnacle shells.

GASTROPODA.—The familiar ecological relationships of *Acmaea testudinalis, A. virginea, Patella vulgata,* and *Helcion pellucidum* are clearly brought out by the Tables.

Gibbula cineraria and *G. umbilicata, Littorina rudis* and *L. obtusata*:—The occurrence of closely allied species side by side is exemplified by these forms.

L. rudis shows a certain response to the humidity of the air by coming out upon the surface of stones in Zone 1 in greater numbers on wet days than on dry days.

Doto coronata was found as usual on a tuft of *Coryne,* which it resembles greatly. Is this association really protective? Experiment alone can answer this question.

AMPHIPODA.—In this group we meet with a striking case of the constant association of one species with another,

namely, of *Hyale nilssoni* with *Gammarus marinus.* They occur commonly on seaweeds, but *G. marinus* is found also under stones. Their association presents an interesting and simple problem for experiment. *Amphithoë rubricata* is not so distinctly a shore form as the other species here tabulated.

ISOPODA.—*Jæra albifrons* seemed specially abundant in Zone 2, Upper. Only the young of *Ligia oceanica* were found below high-water mark. They are remarkably quick in their movements. The adults seem to avoid immersion.[1]

Porcellio scaber, a well-known terrestrial form, was found in the Drift.

BRACHYURA.—The only point deserving mention is the occurrence of megalopas of *Carcinus mænas* in Zone 3.

PYCNOGONIDA.—*Phoxichilidium femoratum* is frequently found in association with little scraps of a dark-red alga *Furcellaria furcata,* to which the adults bear rather a deceptive resemblance.

IV. GENERAL REMARKS.

We must, in the first place, repeat our former statement that we present here, not results of importance in themselves, but an account of an experiment which was designed to test a method in actual working.

The system we have outlined, to produce results of general interest, would require to be in action for at least a year. Further, a series of stations of the same type of shore, and of different types, would have to be examined at regular intervals during a like period. It must not be supposed that the adoption of a "system" relieves the collector of the necessity for alertness in observing inter-relations, which might be missed in the analysis of the tabulated facts. There are many facts which can be more readily discovered by direct observation than by a laborious sifting of accumulated results.

[1] During the printing of these notes we have found (May 1909) numerous adults of *Ligia* sheltering at high tide under stones immersed, close to high-water mark.

The working of such a system is not a task for isolated workers, but one which demands, for each part of the coast, the co-operation of a number of observers, who shall collect, record, and compare results. We may point out the attractive nature of the work, the direct contact it affords with the facts of animal life on the shore, and the added interest and significance which it gives to the work of the collector and systematist.

Now as to the nature of the results which might be expected, if the method were successfully applied to a number of stations. We should be in possession of a systematised body of fact which would be invaluable in further study. We should have a clearer conception of the actual complex of conditions to which animal life is subjected on the shore. This conception would form a setting for the results of other investigations. These might be carried on upon the lines adopted by the authors of the Cold Spring Harbor Monographs referred to above. Indeed, the full value of such work upon the Ecology of single species requires for its realisation some such general view as ours. Or the investigations might be carried on in another way. The analysis of the mass of facts directly suggests certain problems, the solution of which demands experimental inquiry. For instance, the "zoning" of the fauna suggests many experiments to test the reasons for such distribution. It would be a simple and interesting experiment to transfer a small boulder, with its attached fauna, from one zone to another, and observe the changes produced on the fauna. The resistance of shore animals to fresh water might easily be tested by direct experiment. The constant association of two species (*e.g.*, *Hyale nilssoni* with *Gammarus marinus*), one of the facts revealed directly by a method such as ours, presents a problem which is, on the face of it, not so simple. But even this might yield to well-directed experiment.

Perhaps the chief value of such a scheme as we have worked out, and have endeavoured to explain, is that it would lay a foundation for experimental work.

In conclusion, we must thank those who have given us such ready assistance in the identification of specimens:—

Miss Laura Florence, M.A., Aberdeen, to whom we referred Marine Algæ; Miss Agnes S. Brown, Glasgow, who identified Copepods, which were submitted to her only when the lists were in course of final revision; Mr R. Elmhirst, F.L.S., Millport, who named many of the Sponges; Dr J. F. Gemmill, Glasgow University, who looked over all the Polychæta preserved; Mr W. Gordon Pirie, Aberdeen, who identified several of the Polychæta at the time; Mr J. Macgregor Skene, Aberdeen, who worked out the Polyzoa; Mr Alexander Patience, Glasgow, to whom we referred several of the Crustacea; Mr William Evans, F.R.S.E., to whom we are indebted for the identification of the Spiders, and for confirmation of the naming of Collembola; Mr J. J. F. X. King, F.E.S., who named or confirmed all the Coleoptera; and Mr Alexander Ross, Glasgow, to whom we referred specimens of the Diptera.

Most of our own work was done at the Marine Biological Station, Millport, during August 1908, and the preserved material was more completely examined during the winter in the Zoological Laboratory of the Glasgow and West of Scotland Technical College, and in the Embryological Laboratory of Glasgow University.

APPENDIX.

The following appear to be new records for the Clyde:—

Folliculina ampulla (Müll.).
„ *elegans* (Clap. and Lach.).
Chætosoma tristicochæta (Panceri).[1]
Tetrastemma candida (O.F.M.).
Psammoryctes costatus (Clap.).
„ *benedeni* (Udek.).
Theodisca mammillata, Clap. Identified by Dr J. F. Gemmill.
Alcyonidium mytili, Dalyell. Identified by J. M. Skene.
Molgus (*Bdella*) *littoralis* (L.).
Xenylla humicola (O. Fabr.).
Isotoma maritima, Tullb.

Idotea granulosa, Rathke, the only species we found in this area (where it was abundant), appears not to have been previously recorded from Cumbrae.

[1] Schepotieff, Zool. Jahrb. (Syst.) xxvi. (1908).

XXIV. *A Catalogue of Recent Cephalopoda.* Second Supplement, 1897-1906. By WILLIAM E. HOYLE, M.A., D.Sc., Director of the Manchester Museum.

(Received 5th February 1909; read 22nd February 1909.)

In the year 1886, the Royal Physical Society published a "Catalogue of Recent Cephalopoda," and in 1897, a Supplement giving the names of new species published during the decennium 1887-1896. I now venture to lay before it a second Supplement, dealing with the additions made to our knowledge during 1897-1906. So much valuable work has been published during this period, that I have found it advisable to modify the classification then adopted.[1]

The number of new specific names amounts to 69, and of new genera to 29. There has been manifest a distinct tendency to the subdivision of genera, with the result that many of these now only contain one species each. It appears to me that this is a procedure to be deprecated, as tending to conceal the affinities of different forms, and increasing the difficulties of systematic and distributional work. At the same time, it seems an almost inevitable result of specialisation in zoological studies. The student who confines his attention mainly to one group of animals, becomes more and more impressed with their divergences. He recognises large numbers of local races, which his predecessors did not differentiate, and finds it convenient to distinguish these by names, which soon come to be regarded as specific, and almost of necessity the species come to be grouped in more numerous divisions, which naturally receive generic names. Thus we find that of the 29 new generic names above-mentioned, 10 have not been created for the reception of newly-discovered forms, but by dividing or renaming older genera.

Among the most important publications of the decade must unquestionably be reckoned the *Synopsis der oegopsiden Cephalopoden* of Dr Pfeffer, which fitly appeared just at the close of the nineteenth century, and very adequately represented the state of our knowledge of this group at that

[1] Largely because the structure of the hectocotylised arm does not seem to possess the high systematic value attributed to it by Steenstrup; *see* Appellöf, '98; Hoyle, :08.

period. It is a work of remarkable erudition and critical ability. On account of its brevity (it occupies only some 50 pages) it is of necessity very dogmatic in tone, and the reader misses the evidence on which the various judgments are based. It is a striking instance of the subdivision of genera referred to above, for of the 50 generic groups recognised, no less than 43 are monotypic.

The interesting results of the expeditions of the Prince of Monaco have been given to the world by Professor Joubin, in two splendid Memoirs, got up and illustrated in truly princely style, and a number of smaller papers. In this connection must be mentioned the discovery, that a very large number of Cephalopoda possess luminous organs of varied and often complex structure; for which science is largely indebted to the labours of Professor Joubin and Professor Chun.

A very important event of the last few years has been the rise of what may be called the "Leipzig school" of teuthologists. The cruise of the "Valdivia" furnished Professor Chun with examples of many of the rarest species of Cephalopods, as well as with a large number of new and remarkable forms, and it is therefore not wonderful that he and his students, among whom we may mention the names of Meyer and Marchand, should have been inspired to enter upon the study of these interesting animals. Several important papers have already proceeded from their pens, and the publication of the report on the "Valdivia" collection will mark an epoch in this branch of science.

In preparing this Supplement, I have not confined myself to the enumeration of new species, but have recorded the instances in which a species has been removed from one genus to another. For the sake of convenience, too, a few species described since the close of the year 1906 have been included, but the list does not pretend to completeness after that date.

The Bibliography, taken in conjunction with the references given in the earlier parts of the Catalogue, will, it is thought, be found to include all important writings dealing with the systematic aspect of the subject. The figures given in the text refer to the year of publication, the centuries being indicated as follows:—17 - - ‘, 18 - - ’, 19 - - :

When two or more papers by the same author have appeared in one year, they are distinguished by letters of the alphabet.

As regards nomenclature, the regulations and recommendations of the Commission of the International Zoological Congress have been adopted, and some pains have been taken to ascertain the dates of publication as accurately as possible. There are, however, difficulties in this task, depending especially on the uncertainty of the dates of publication of Férussac and d'Orbigny's monumental work. When these can be definitely ascertained, changes in the accepted dates of publication of some species will probably result, along with one or two changes of name; but, so far as I can see, these are not likely to be either numerous or important. In this connection, I have to acknowledge the invaluable help of my friend, Mr C. Davies Sherborn, whose enthusiastic and self-denying labours in the compilation of the *Index Animalium* are known to and appreciated by all systematists. I must also place on record my indebtedness to the card catalogue of zoological literature, issuing from the Concilium Bibliographicum at Zürich, under the direction of Dr Field.

OCTOPODA.

Cirroteuthidæ, Keferstein, 1866.

Cirroteuthis, Eschricht, 1836.

C. grimaldii, Joubin, :03, p. 100 (*nomen nudum*); Richard, :03, p. 70. [N.N.W. of Fayal, 1900 metres.]

C. muelleri, Eschricht, 1836.

Cirroteuthis Mülleri, Appellöf, '99 [shell]; Friele & Grieg, :01.

C. richardi, Joubin, :03, p. 101 (*nomen nudum*). [Off Cape Verde Is., 3890 metres.]

C. umbellata, Fischer, 1883.[1]

Cirroteuthis umbellata, Joubin, :01, p. 21, pl. i. fig. 1; pl. iii. figs. 1-5; pl. xii. fig. 3.

Cirroteuthis sp., Hoyle [:05a]. [Irish coast].

[1] I think it highly probable that this species should be referred to the genus *Stauroteuthis*, and quite possible that it is synonymous with *S. hippocrepium*, but Joubin gives no particulars regarding the form and position of the internal cartilage.

Stauroteuthis, Verrill, 1879.[1]

S. hippocrepium, Hoyle, **:04**, p. 6, pl. i. fig. 1; pl. ii. fig. 1; pl. iii. figs. 1-4. [Off Malpelo Is., Gulf of Panama.]

S. meangensis, Hoyle, **:04**, p. 5.

Cirroteuthis meangensis, Hoyle, 1885: **'86**, p. 63, pl. ix. figs. 12, 13; pl. xi. figs. 1, 2; pl. xiii. figs. 5, 6.
,, ,, Lo Bianco, **:03**, p. 173 [Mediterranean].

Froekenia, Hoyle, **:04**.

F. clara, Hoyle, **:04**, p. 7, pl. ii. fig. 2; pl. iii. fig. 5. [Off Cape Mala, Gulf of Panama.]

Opisthoteuthis, Verrill, 1883.[2]

O. depressa, Ijima & Ikeda, 1895.

Opisthoteuthis depressa, Meyer, **:06** [anatomy].

AMPHITRETIDÆ, Hoyle, 1886.

Amphitretus, Hoyle, 1885.

A. pelagicus, Hoyle, 1885.

Amphitretus pelagicus, Ijima & Ikeda, **:02**, p. 85, pl. [description and figure of fresh specimen].
Amphitretus sp., Chun, **:03** [description of eyes].

ALLOPOSIDÆ, Verrill, 1881.

Alloposus, Verrill, 1881.

A. pacificus, Ijima, *in* Ijima & Ikeda, **:02**, p. 87.

Bolitæna, Steenstrup, 1859.[3]

B. microcotyla, Steenstrup, 1859.

Bolitæna microcotyla, Hoyle, **:04**, p. 9, pl. iii. figs. 6-11; pl. iv. fig. 1 [description of young specimen].

ARGONAUTIDÆ, Cantraine, 1851.

Argonauta, Linné, 1758.

A. argo, Linné, 1758.

Argonauta argo, Brazier, **'92**, p. 1 [Port Jackson Heads, etc.].
,, ,, Hoyle, **:04**, p. 12 [Eastern Pacific].
,, *compressa*, Hidalgo, **:05**, p. 9 [Philippines].

[1] For the relation between this genus and *Cirroteuthis*, see Hoyle, **'04**, p. 5.

[2] For a discussion of the general morphology of this genus, see Verrill, **'96**, who makes it the type of a distinct family; his conclusions, however, are disputed by Meyer, **:06**.

[3] Chun, **:02**, regards *Eledonella* as a synonym of this genus; he describes the development of the chromatophores.

A. argo, *var.* **americana**, White, '96. [Florida; no description.]

A. boettgeri, Maltzan, 1881.

Argonauta Böttgeri, Hidalgo, :05, p. 9 [Masbate, Philippines].

A. expansa, Dall, 1872; Dall, :02, p. 511, pl. xxxiii. figs. 1-3. [Figure; Gulf of California.]

A. hians, Solander, 1786.

Argonauta hians, Brazier, '92, p. 2 [Moreton Bay, Queensland].
,, ,, Hoyle, :04, p. 11 [North Pacific].
,, ,, *A. Gondola*, *A. Oweni*, Hidalgo, :05, p. 9 [Philippines].

A. rufa, Owen, '36, p. 114, footnote. [*Nomen nudum*].

A. tuberculata, Bolten, '98, p. 71.

Argonauta tuberculatus, Shaw, Nat. miscell., vol. xxiii., pl. 995, 1811.
,, *nodosa*, Brazier, '92, p. 2 [Outer Manly Beach, Newcastle, Port Stephens, Tasmania].
,, *tuberculata*, Hidalgo, :05, p. 9 [Philippines].

Ocythoe, Rafinesque, 1814.

O. tuberculata, Rafinesque, 1814.

Ocythoe tuberculata, Meyer, :06 [morphology of male genital organs in this and other species].

Tremoctopus, delle Chiaje, 1840.

T. quoyanus (d'Orbigny, 1835).

Tremoctopus quoyanus, Hoyle, :04, p. 12 [young form; tropical Pacific].

T. joubini, n.n.[1]

Tremoctopus microstoma, Joubin, 1893, p. 218.

T. scalenus, Hoyle, :04, p. 13, pl. iv. figs. 6-9. [Off Cape Mala, Gulf of Panama.]

POLYPODIDÆ, n.n.

Polypus, Schneider, '84, p. 116

Octopus, Auctorum.

For the reasons for replacing the old established name *Octopus* by *Polypus*, see Hoyle, :01a; also Smith, :07.

P. arborescens, Hoyle, :04a, p. 189, pl. ii. figs. 8, 9, 12; pl. iii. [Ceylon]: :05, p. 979. [Pacific Ocean.]

P arcticus (Prosch, 1847).

Octopus arcticus, Appellöf, '93, p. 3 [no ink-sac]; '99, pl. i. figs. 2, 4 [internal shell]; Friele & Grieg, :01.
,, ,, Grieg, '96, p. 24 [Bergen fjord].
,, *groenlandicus?*, Friele, '79, p. 284.

[1] The name proposed by Joubin is preoccupied by *Octopus microstoma*, Reynaud, 1831 (= *Tremoctopus microstomus*, Tryon, 1879, p. 131).

P. areolatus (de Haan, MS., d'Orbigny, 1835).
Octopus areolatus, Joubin, '98b, p. 22 [Japan].
,, *ocellatus*, Joubin, '98b, p. 22 [Amboina].

P. australis (Hoyle, 1885).
Octopus australis, Brazier, '92, p. 5 [George's Beach, Port Jackson, N.S.W.].

P. bandensis (Hoyle, 1885).
O. bandensis, Appellöf, '98, p. 566 [Ternate].

P. bosci, (Lesueur, 1822).[1]
Polypus bosci, Hoyle, :04a, p. 195 [Ceylon].

P. campbelli, Smith, :02, p. 201, pls. 24, 25. [Antarctic.]

P. cephea (Gray, 1849), Smith, :07 [branched arms].

P. chierchiæ (Jatta, 1889).
Octopus chierchiæ, Jatta, '99, p. 19, pl. i. figs. 3-14 [full description].

P. cyanea (Gray, 1849).
Octopus cyanea, Brazier, '92, p. 7 [Port Jackson, N.S.W.; Moreton Bay, Queensland; Uji, Solomon Is.].

P. de-filippii (Vérany, 1851).
Octopus de-filippii, Bergmann, :03 [Receptaculum seminis].

P. duplex (Hoyle, 1885).
Octopus duplex, Appellöf, '98, p. 567 [Ternate].

P. faeroensis, Russell, :09, p. 446. [Faeroe Channel.]

P. fontanianus (d'Orbigny, 1835).
Octopus fontanianus, Joubin, '98b, p. 23 [Indian Ocean].

P. gardineri, Hoyle, :05. [Laccadive and Maldive Is., Male Atoll.]

P. globosus (Appellöf, 1886).
Octopus globosus, Appellöf, '98, p. 565 [Ternate]; Joubin, '97a.

P. granulatus (Lamarck, :98, p. 130).[1]
Octopus granulatus, Brazier, '92, p. 4 [Port Jackson, N.S.W.].
,, ,, var. *rugosa*, Joubin, '98b, p. 22 [Bahama].
Polypus granulatus, Hoyle, :04a, p. 195 [Ceylon].

P. herdmani, Hoyle, :04a, p. 187, pl. i. [Ceylon.]

P. hoeki (Joubin).
Octopus Hoeki, Joubin, '98b, p. 24 [Amboina].

P. horridus (d'Orbigny, 1826).
Polypus horridus, Hoyle, :04a, p. 194, pl. ii. figs. 10, 13 [Ceylon] (erroneously entered as *P. aculeatus*).
,, ,, Hoyle, :05, p. 978 [Male Atoll].

P. horsti (Joubin).
Octopus Horsti, Joubin, '98b, p. 23 [Djeddah, Red Sea].

P. inconspicuus (Brock, 1887).
Octopus inconspicuus, Appellöf, '98, p. 564 [Ternate].

[1] Joubin, '97a, regards these as synonyms, and adopts the name *O. rugosus*, Bosc.

P. januarii (Steenstrup, MS., Hoyle, 1885).
Polypus januarii, Hoyle, **:04**, p. 18 [off Cocos Is., tropical Pacific].

P. lentus (Verrill, 1880).
Octopus lentus, Appellöf, **'93**, p. 4 [no ink-sac].
,, ,, Grieg, **'96**, p. 24 [Bergen fjord]; Friele & Grieg, **:01**.

P. lunulatus (Quoy & Gaimard, 1832).
Octopus lunulatus, Brazier, **'92**, p. 6 [Torres Straits; Uji, Solomon Is.].

P. macropus (Risso, 1826).
Octopus macropus, Brazier, **'92**, p. 6 [Port Jackson, N.S.W.].
,, ,, Lönnberg, **'97a**, p. 706 [Teneriffe]; Joubin, **'97a**.
Polypus macropus ?, Hoyle, **:04**, p. 18 [Marshall Is., Pacific Ocean].
,, ,, Hoyle, **:04a**, p. 195 [Ceylon].

P. maorum (Hutton, 1880).
Octopus maorum, Filhol, **'85**, p. 520 [Stewart Island; Halfmoon Bay].

P. marmoratus (Hoyle, 1885).
Polypus marmoratus, Hoyle, **:05**, p. 978 [Rotuma, Pacific Ocean].

P. mollis (Gould, 1852).
Octopus mollis (?), Appellöf, **'98**, p. 566 [Ternate].

P. normani, Massy.
Polypus Normani, Massy, **:07**, p. 379 [off S.W. Ireland].

P. occidentalis (Steenstrup, MS., Hoyle, 1886).
P. occidentalis, Hoyle, **:04**, p. 14 [Galapagos Is.].

P. oculifer, Hoyle, **:04**, p. 14, pl. iv. figs. 3, 4. [Galapagos Is.].

P. patagonicus (Lönnberg).
Octopus patagonicus, Lönnberg, **'98**, p. 50 [Punta Arenas; Puerto Churruca].

P. pictus (Brock, 1882).
Octopus pictus, Appellöf, **'98**, p. 568 [Ternate].
Polypus pictus, Hoyle, **:05**, p. 979 [Mulaku Atoll].

P. piscatorum (Verrill, 1879).
Octopus piscatorum, Appellöf, **'93**, p. 3 [no ink-sac].

P. profundicola, Massy.
Polypus profundicola, Massy, **:07**, p. 377 [off S.W. Ireland].

P. punctatus (Gabb, 1863).
Octopus punctatus, Joubin, **'97**, pl. 9; **'97a** [Kamtschatka]; Baily, **:07**.

P. pusillus (Gould, 1852).
Polypus pusillus, Hoyle, **:04**, p. 16, pl. 4 fig. 5 [Gulf of Panama, Cocos Is.].

P. tonganus (Hoyle, 1885).
Octopus tonganus, Hedley, **'99**, pp. 520, 550 [Funafuti].
Polypus ,, Hoyle, **:04**, p. 17, [Eastern Pacific].
,, ,, Hoyle, **:05**, p. 978 [Male Atoll].

P. tuberculatus (Blainville, 1826).
Octopus tuberculatus, Lönnberg, **'97a**, p. 706 [Teneriffe].

P. vitiensis (Hoyle, 1885).
Octopus vitiensis, Appellöf, **'98**, p. 563 [Ternate].

P. vulgaris (Lamarck, :98, p. 130).

Octopus vulgaris, Lönnberg, '97a, p. 706 [Teneriffe].
,, ,, Garstang, :00, p. 260 [plague in English Channel].
,, ,, Parona, :00, [bifurcate arm].

Scæurgus, Troschel, 1857.

S. tetracirrus (delle Chiaje, MS. *in* d'Orbigny, 1840).

Scæurgus tetracirrus, Joubin, :01, p. 36, pl. iii. fig. 6 [coloured figure of living specimen ; off the Azores].
,, ,, Lo Bianco, :03 [young specimen figured].

Pinnoctopus, d'Orbigny, 1845.

P. cordiformis (Quoy & Gaimard, 1832).

Pinnoctopus cordiformis, Filhol, '85, p. 521 [Campbell Is.; Stewart Is.; mouth of Nelson Harbour].

Moschites, Schneider :84, p. 118.

Eledone, Auctorum.

For the reasons for preferring the name *Moschites* to *Eledone* see Hoyle, :01a. In addition to the reasons there given, I have since ascertained that the name *Eledona*, differently derived, had been used by Latreille for a Beetle, so early as 1796, *Précis caract. Insectes*, Brive, An v., p. 19.

M. charcoti (Joubin).

Eledone Charcoti, Joubin, :05a, p. 22, pl. iii. figs. 1, 2; :06, pp. 2-9, pl. i. figs. 1, 2.

M. cirrosa (Lamarck, :98, p. 130).[1]

Eledone cirrosa, Appellöf, '93 [case of bilateral hectocotylus]; '99 [existence of an internal shell].

M. moschata, Lamarck, :98, p. 130.

Eledone moschata, Babor, :02 [Cephalic cartilage]; Parona, :00, [branched arm].

M. rotunda (Hoyle, 1885) :04, p. 21. [Off Cape San Francisco, Gulf of Panama.]

M. turqueti (Joubin).

Eledone Turqueti, Joubin, :05a, p. 29, pl. iii. figs. 3-6; :06, pp. 9-11, pl. i. figs. 3-6.

M. verrucosa (Verrill, 1881).

Moschites verrucosa, Hoyle, :04, p. 21 [off Cape Mala, Gulf of Panama].

Eledonella, Verrill, 1884.

Chun (:02) is of opinion that this genus is synonymous with *Bolitæna*, Stp.

[1] Russell (:09) regards this as identical with the Mediterranean *M. aldrovandi*. Case of extra arm, Parona, :00.

E. diaphana, Hoyle, 1885.

Eledonella diaphana, Joubin, **:03**, p. 101 [off Cape Verde].
,, ,, Hoyle, **:04**, p. 22, pl. v. fig. 11 [Tropical Pacific].

Japetella, Hoyle, 1885.

J. prismatica, Hoyle, **:04**, p. 23, pl. v. figs. 10, 12. [Eastern Pacific.]

Vampyroteuthis, Chun, **:03**.

Vampyroteuthis sp., Chun, **:03**, p. 88. [*Nomen tantum.*

DECAPODA.

Myopsida.

Idiosepiidæ, Appellöf, **'98**.

Idiosepius, Steenstrup, 1881.

Microteuthis, Ortmann (1888) is beyond all reasonable doubt a synonym of this.

I. pygmæus, Steenstrup, 1881; Appellöf, **'98**, pp. 572-593. [Anatomical description.]

Sepiolidæ, Leach, 1817 (*em.*).

A revision of this family has been published by Joubin, **:02a**; *see also* Steenstrup, **:00**; luminous organs, Meyer, **:06a.**

Sepiola, Leach, 1817.

The value of the shape of the ink-sac (whether pyriform or trilobed) as a specific character in this genus is discussed by Jatta, **:04**, p. 204.

S. aurantiaca, Jatta, 1896.

The specific distinctness of this form is defended by its author, **:04**, p. 206, against the criticisms of Joubin, **:02a**, p. 85; *see also* Russell, **:09.**

S. oweniana, d'Orbigny, 1839.[1]

Sepiola oweniana, Ostroumoff, **'96**, p. 74.

S. rondeleti, Leach, 1817.

Sepiola Rondeletii, Brazier, **'92**, p. 8 [Iron Stone Cove, Port Jackson, N.S.W.].
Sepiola rondeleti, Appellöf, **'98**, pl. xxii. fig. 6; pl. xxiv. fig. 28 [anatomy].
,, ,, Godfrey, **:00**, p. 125 [Firth of Forth].
Sepiola rondeletii, Grieg **'96**, p. 23 [Norwegian coast].
,, ,, Meyer, **:06a**, p. 388 [luminous organs].

S. rossiæformis, Pfeffer, 1884; Joubin, **'97a.**

[1] Pfeffer (**:08**, p. 49) regards *S. scandica*, Steenstrup, *S. petersii*, Stp., *S. rondeletii*, Auctt. (*partim*), and *S. aurantiaca*, Jatta, as synonyms of this.

S. scandica, Steenstrup, 1887.

Sepiola scandica, Appellöf, **'98**, pl. xxi. fig. 8; pl. xxiii. figs. 15-17 [anatomy].

S. scandica, var. **macrocephala**, Fischer, H., & Joubin, **:06**, p. 204; **:07**, p. 329, pl. xxiv. figs. 1, 2.

Inioteuthis, Verrill, 1881.

I. maculosa, Goodrich, 1896.

Inioteuthis maculosa, Hoyle, **:04a**, p. 198 [Ceylon].

Euprymna, Steenstrup, '87, p. 66 (20).

E. stenodactyla (Grant, 1833).

Euprymna stenodactyla, Hoyle, **:04**, p. 24, figs. B-D [specimens with hectocotylised arms described; Tropical Pacific].

Inioteuthis stenodactyla, Brazier, **'92**, p. 9 [Port Jackson].

Sepiola stenodactyla, Jatta, **'99**, p. 22, pl. i. figs. 5-24 [full description].

E. morsei (Verrill, 1881).

Euprymna morsei, Hoyle, **:04a**, p. 198 [Ceylon].

,, ,, Hoyle, **:05**, p. 981 [Kolumadulu Atoll].

Inioteuthis Morsei, Joubin, **'97a** [dimensions].

E. tasmanica (Pfeffer, 1884).

Inioteuthis tasmanica, Tate & May, **:01**, p. 351.

The genus may be regarded as including provisionally the following additional forms:—

E. pusilla (Pfeffer, 1884).

E. schneehageni (Pfeffer, 1884).

Sepiadarium, Steenstrup, 1881.

S. kochi, Steenstrup, 1881.

Sepiadarium kochii, Appellöf, **'98**, p. 593, pl. xxii. figs. 9, 10; pl. xxiii. figs. 19, 21; pl. xxiv. figs. 23, 25, 27 [anatomy].

,, ,, Hoyle, **:04a**, p. 198 [Ceylon].

Rossia, Owen, 1834.

R. caroli, Joubin.

Rossia Caroli, Joubin, **:02a**, p. 136, figs. 34-36 [Azores, 1098 metres]; **:02b**, p. 138, figs. 1, 2; **:03**, p. 101 [Canary Is.].

R. glaucopis, Lovén, 1845.

Rossia glaucopis, Appellöf, **'93**, p. 7 [off north of Norway, 123-223 fathoms]; **'98**, pl. xxiii. fig. 18 [anatomy].

,, ,, Grieg, **'96**, p. 23 [west coast of Norway, 60-150 fathoms].

,, ,, Friele, **'79**, p. 284; Krause, **'92** [Spitzbergen].

,, ,, Lönnberg, **'91**, p. 13 [Swedish coast]; **'99** [77° N. 27° E.].

,, ,, Friele & Grieg, **:01**.

Norman (**'90**, p. 470) makes this species the type of a subgenus *Franklinia*, including also *R. megaptera* and *R. tenera* of Verrill; the name *Franklinia* is preoccupied

by Blyth (1863) for a genus of Birds. Pfeffer (:08, p. 37) includes as synonyms *R. papillifera*, Jeffreys; *R. sublevis*, Verrill; *R. hyatti*, Verrill; and *R. palpebrosa*, Owen.

R. macrosoma (delle Chiaje, 1829).

Rossia macrosoma, Norman, '90, p. 469 [regards *R. oweni* as being not more than a variety; rightly I think].

,, ,, Appellöf, '93, p. 8, fig. 4.

,, ,, Friele, '79, p. 284.

,, *megaptera*, Verrill, 1881.

R. moelleri, Steenstrup, 1856.

Rossia mölleri, Knipowitsch, :02 [figured, with radula].

R. palpebrosa, Owen, 1834.

Rossia palpebrosa, Appellöf, '93, p. 7, fig. 7 [80° 3′ N., 8° 28′ E.].

,, ,, Friele & Grieg, :01.

R. sublevis, Verrill, 1878.

Rossia sublevis, Norman, '90, p. 471 [off the south of Ireland; Norman also expresses the opinion that this is probably a synonym of *R. glaucopis*].

Semirossia, Steenstrup, '87a, p. 90 [44].

S. patagonica (E. A. Smith, 1881).[1]

S. tenera (Verrill, 1880).[1]

Heteroteuthis tenera, Verrill, 1880.

Heteroteuthis, Gray, 1849.

H. weberi, Joubin.

Heteroteuthis Weberi, Joubin, :02a, p. 113, four figs.; :02c.

LOLIGINIDÆ, d'Orbigny, '45 (*em*).

Loligo, Schneider, '84, p. 110.

L. australis, Gray, 1849.

Loligo australis, Brazier, '92, p. 15 [Port Jackson, Newcastle, Port Stephens, N.S.W.].

L. brevipennis, Pfeffer, 1884.

Loligo brevipennis, Hedley, '99, p. 520 [Funafuti].

L. diomedeæ, Hoyle, :04, p. 29, pl. v. fig. 13; pl. vi. figs. 1-7. [Off Acapulco.]

L. edulis, Hoyle, 1885.

Loligo edulis, Brazier, '92, p. 16 [Port Jackson, N.S.W.].

L. forbesi, Steenstrup, 1856.

Loligo forbesi, Aurivillius, '98, p. 45 [Skagerak, Baltic].

L. indica, Pfeffer, 1884.

Goodrich ('96, p. 7) is of opinion that the form described under this name in the "Challenger" Report (Hoyle, '86,

[1] Pfeffer (:08, p. 45) regards these two species as identical.

p. 156) is not correctly referred to this species. Judging from his description this may be so, but my drawings were submitted to Dr Pfeffer for comparison with the type.

L. media, (Linné, 1758).

Loligo media, Joubin, :02, includes *L. marmoræ* and several other names as synonyms; this opinion is shared by Kolombatovic, :05, and refuted by Jatta, :04, p. 198; *see also* Massy, :08.

L. vulgaris, Lamarck, :98, p. 130.

Loligo vulgaris, Lönnberg, '97a, p. 706 [Teneriffe].
,, ,, Aurivillius, '98, p. 46 [Strömstad; Travemünde].

Sepioteuthis, Blainville, 1825.

S. lessoniana, Lesson, 1830.[1]

Sepioteuthis Lessoniana, Brazier, '92, p. 14 [Uji Is., Solomon Is.].
,, ,, Joubin, '98b, p. 26 [several Indo-Malayan localities; regards *S. mauritiana* as identical].

S. lunulata, Quoy & Gaimard, 1832.

Sepioteuthis lunulata, Brazier, '92, p. 13 [Solomon Is.].
,, ,, Hoyle, :04, p. 31 [Marshall Is.].

S. mauritiana, Quoy & Gaimard, 1832.

Sepioteuthis mauritiana, Brazier, '92, p. 15 [Port Jackson, N.S.W.].

S. sieboldi, Joubin.

Sepioteuthis Sieboldi, Joubin, '98b, p. 27 [Waigeou; Japan].

Sepiidæ, d'Orbigny, '45.

Sepia, Linné, 1758.

S. aculeata, van Hasselt, MS., *in* d'Orbigny, 1834.

Sepia aculeata, Joubin, '98b, p. 25 [St Vincent, Nassau Harbour; thinks *S. indica*, d'Orb., very likely identical].

S. apama, Gray, 1849.

Sepia apama, Brazier, '92, p. 11 [S. Australia].

S. australis, Quoy & Gaimard, 1832.

Sepia capensis, d'Orbigny, '34, *in:* Fér. & d'Orb., p. 278, pl. vii. figs. 1-3 (1834).
,, ,, Brazier, '92, p. 13 [N.S. Wales coast, and N. Queensland].

S. braggi, Verco, :07, pp. 213, 214, p. 27. [Glenelg, S. Australia.]

Sepia braggi, Hedley, :08, p. 134.

S. burnupi, Hoyle, :04b, p. 27, pl. i. [Natal.]

S. cultrata, Hoyle, 1885; Hedley, :06, p. 468. [Queensland.]

S. esculenta, Hoyle, 1885; Hedley, :06, p. 468. [Queensland.]

S. hierredda, Rang, 1837.

Sepia hierredda, Lönnberg, '97a, p. 706 [Teneriffe].

[1] This species is usually attributed to Férussac on the strength of d'Orbigny, '26, p. 65, but neither description nor figure is there given: the first writer to give a diagnosis is Lesson (Voy. "Coquille," p. 241, pl. xi., 1830).

S. hungarica, Lörenthey, '99, p. 317. [Hungarian, tertiary.]

S. indica, d'Orbigny, 1839.

Sepia indica, Brazier, '92, p. 12 [West Australia ; Cape Upstart, N.E. Australia].

S. kobiensis, Hoyle, 1885.

Sepia kobiensis, Hoyle, :05, p. 982 [Kolumadulu Atoll, Pacific Ocean].

S. koettlitzi, Hoyle, *in* Hoyle & Standen, :01. [Red Sea.]

S. mestus, Gray, 1849.

Sepia mestus, Brazier, '92, p. 12 [coast of New South Wales].
,, ,, Tate & May, :01, p. 351 [Tasmania].

S. novae-hollandiæ, n.n.[1]

Sepia australis, d'Orbigny, *in:* Fér. & d'Orb., '34, p. 285, pl. vii. fig 4 (1834).
,, ,, Brazier, '92, p. 12 [Kangaroo Is., S. Australia].

S. officinalis, Linné, 1758.

S. officinalis, Burne, '98 ; Hescheler, :02 [anatomy].

S. orbignyana, Férussac, 1826.

S. Orbignyana, Fischer, '97 [hectocotylised arm].

S. palmata, Owen, 1881.

Sepia palmata, Brazier, '92, p. 13 [N. Queensland coast].

S. papuensis, Hoyle, 1885.

Sepia papuensis, Appellöf, '98, p. 561 [Ternate] ; Joubin, '97a.

S. pfefferi, Hoyle, 1885 ; Hedley, :06, p. 468. [Queensland].

S. rouxi, d'Orbigny, 1839.

Sepia rouxi, Hoyle, :04a, p. 198 [off Negombo, Ceylon].

S. singalensis, Goodrich, 1896.

Sepia singalensis, Hoyle, :04a, p. 198 [Gulf of Manaar].

S. tuberculata, Lamarck, '98, p. 130.

S. venustoides, n.n.

Sepia venusta, Pfeffer, '84, p. 12, fig. 15.
,, ,, Hoyle, :05, p. 982 [S. Nilander Atoll].

S. veranyi, P. Fischer, *in* Lagatu.[2]

Sepia Veranyi, Lagatu, '88, p. 115, pl. viii.

S. verrucosa, Lönnberg, '97a, p. 697 [Teneriffe].

Sepiella, Gray, 1849.

S. inermis (van Hasselt, MS., *in* Fér. and d'Orb., 1834).

Sepiella inermis, Joubin, '98b, p. 25 [Timor].
,, ,, Hoyle, :05, p. 982, fig. 152 [hectocotylised arm ; Male Atoll] ; Joubin, '97a [Japan].

[1] Quoy & Gaimard's use of the name *australis* has unquestionable priority over d'Orbigny's, and his species must therefore be renamed.

[2] Lagatu (*op. cit.*) gives diagnostic characters for *S. fischeri*, *S. filliouxi*, *S. veranyi*, and *S. officinalis* (*sensu strictiori*) : they do not seem to me adequate.

SPIRULIDÆ, Keferstein, 1866.[1]

Spirula, Lamarck, 1801.

S. spirula (Linné, 1758).

Spirula Peroni, Huxley & Pelseneer, '95.
,, *reticulata*, Lönnberg, '96, p. 97.
,, *australis*, Giard, '93.
,, *Peronii*, Verrill, :01, p. 23 [Elbow Bay, Bermudas].

S. blakei, Lönnberg, '96, p. 101.

Œgopsida.

GONATIDÆ, Hoyle, '86 (as a subfamily).

Gonatus, Gray, 1849.

G. fabricii (Lichtenstein, 1818).

Gonatus fabricii, Appellöf, '93, p. 9, figs. 1-3, 5, 6, and 8; Loennberg, '99.
,, ,, Massy, :07, p. 381 [S.W. Ireland]; Friele & Grieg, :01.

G. antarcticus, Lönnberg, '98, p. 51. [Punta Arenas.]

ONYCHOTEUTHIDÆ, Gray, 1849.

Onychoteuthis, Lichtenstein, 1818.

O. banksi (Leach, 1817).

Onychoteuthis banksi, Pfeffer, :00, p. 159 [Mediterranean; diagnosis from *Ancistroteuthis lichtensteini*].
,, ,, Jatta, :04, p. 200 [? young of *A. lichtensteini*].

O. rutilus, Gould, 1852.

Onychoteuthis rutilus, Tate & May, :01, p. 351 [Tasmania].

Ancistroteuthis, Gray, 1849.

A. lichtensteini (Férussac, 1848).

Ancistroteuthis lichtensteini, Pfeffer, :00, pp. 159, 160 [differential diagnosis from *Onychoteuthis banksi*].

Teleoteuthis, Verrill, 1882.

T. caribbæa (Lesueur, 1821).

Teleoteuthis caribbæa, Hoyle, :04, p. 35 [N. Pacific, N. of Marquesas Is.].
Steenstrupiola atlantica, Pfeffer, :00, p. 157.

T. appellöfi, Pfeffer, :00, pp. 157, 158. [Atlantic Ocean.]

T. caroli, Joubin, '99, p. 70; :01, p. 64. [Bay of Biscay.]

T. jattai, Joubin, '99, p. 70; :01, p. 67. [S.W. of Madeira.]

[1] For a discussion of the position of this family see Hoyle, :08; according to a communication made by Professor Chun to the Deutsche Zoologische Gesellschaft at Frankfort on 3rd June 1909, there can be no doubt that *Spirula* is a Myopsid. It is uncertain how many valid species of *Spirula* exist.

T. platyptera (d'Orbigny, 1835).
Steenstrupiola chilensis, Pfeffer, '84, p. 16, pl. iii., figs. 20, 20a.
T. verrilli, Pfeffer, :00, pp. 157, 158. [46° S., 147° E.]

Teleonychoteuthis, Pfeffer, :00, p. 155.

T. krohni (Vérany, 1851).
Teleonychoteuthis krohni, Pfeffer, :00, p. 158.

Tetronychoteuthis, Pfeffer, :00, pp. 156, 161.

T. dussumieri (d'Orbigny, 1848).
Tetronychoteuthis dussumieri, Pfeffer, :00, pp. 156, 161.
Onychoteuthis dussumieri, Hoyle, :01 [possible explanation of integument.

Moroteuthis, Verrill, 1881.

M. ingens (Smith, 1881).
Onychoteuthis ingens, Smith, 1881 (*see* this Catalogue, part 1, p. 250).
,, ,, Lönnberg, '98, p. 55, pls. iv., v. [anatomical details].
Moroteuthis ingens, Pfeffer, :08, p. 68 ; :08a, p. 294.
M. robusta (Dall, *in* Verrill, 1876). (*See* this Catalogue, part 1, p. 251.)
Ancistroteuthis robusta, Thompson, :01a, p. 992 [structure of tentacle and pen] ; :01 [Marks on Cetacea].
Moroteuthis robusta, Pfeffer, :00, pp. 156, 161 ; :08, p. 68 ; :08a, p. 294.

Lepidoteuthis, Joubin, 1895, :01.

L. grimaldii, Joubin, 1895, :01, p. 70, pls. vi., vii., x. figs. 3-6, and pl. xv. figs. 1, 2.
Onychoteuthis ingens, Lönnberg, '98, p. 61.
Lepidoteuthis grimaldii, Pfeffer, :00, p. 160.

The systematic position of this interesting specimen is still uncertain ; I have left it as placed by the original describer.

Subfamily Lycoteuthinæ, Pfeffer, :08a.

Lycoteuthis, Pfeffer, :00.

Thaumatolampas, Chun, :03.

L. diadema (Chun).[1]
Enoploteuthis diadema, Chun, :00, p. 532, fig.
Lycoteuthis jattai, Pfeffer, :00, p. 161 [West coast of America].
Thaumatolampas sp., Chun, :03.
Lycoteuthis diadema, Pfeffer, :08a, p. 294.

[1] Chun, :03, regards this form as the type of a separate family, with the name Thaumatolampadidæ.

ENOPLOTEUTHIDÆ, Pfeffer, :00, pp. 152, 163.

Abralia, Gray, 1849.

A. lineata, Goodrich, 1896.

Pfeffer, :00, pp. 165, 167, makes this the type of a new genus *Micrabralia*.

A. veranyi (Rüppell, 1844).

Enoploteuthis Verany, Ficalbi, '99, p. 82, fig. 2 [reprint of original description and figure].

Abraliopsis, Joubin, 1896.

A. hoylei (Pfeffer, 1884).

Abraliopsis sp., Chun, :03, p. 78 [luminous organs].

,, *hoylei*, Hoyle, :04, p. 36, pl. i. fig. 3, pl. viii. [description, luminous organs; Eastern Pacific].

,, sp., Chun, :05, p. 653 [male organs].

Abraliopsis sp., Nishikawa, :06a. [Pelagic eggs and embryos].

[Since the above was written, Pfeffer :08a, has just published the view that *Onychoteuthis armata*, Quoy & Gaimard, and *Onychoteuthis morisii*, Vérany, are congeneric with *Abraliopsis hoylei:* if this be so, then, since the first named is the type of Gray's *Abralia*, this generic name must be applied to these three species, and the name *Abraliopsis* must lapse. *Enoploteuthis veranyi* and *E. oweni*, which have of late been placed in *Abralia*, are generically distinct from the three first-named, and the generic name *Asteroteuthis* is proposed for their reception. The question must stand over for future discussion: the adoption of Pfeffer's view would result in the following arrangement:—

ABRALIA, Gray, 1849: *A. armata* (Q. & G.), *A. morisii* (Vér.), *A. hoylei* (Pfr.).

ASTEROTEUTHIS, Pfeffer, 1908: *A. veranyi* (Rüpp.), *A. oweni* (Vér.).

Pfeffer regards the last two species as identical, and adopts the name *A. veranyi*, dating from 1844, and thus having two years priority over *A. oweni*, which was, I believe, published in 1846 (*see* Vérany, '46, p. 29, pl. iv. figs. 2, 3)].

Thelidioteuthis, Pfeffer, :00, p. 165.

T. polyonyx (Troschel, 1857).

Enoploteuthis pallida, Pfeffer, '84, p. 18, figs. 23, 23a, 23b.

Thelidioteuthis polyonyx, Pfeffer, :00, p. 167 [Barbados; S. Atlantic; Society Is.].

Abralia megalops, Verrill, 1882.

Ancistrochirus, Gray, 1849.

A. lesueuri (Fér. & d'Orb., 1848).

Ancistrochirus lesueuri, Hoyle, **:05**, p. 983, pl. xcv. fig. 153 [description of specimen; structure of luminous organs; Felidu Atoll].

Enoploteuthis lesueuri, Pilsbry & Vanatta, **:02** [stomach of shark].

Compsoteuthis, Pfeffer, **:00.**

C. loennbergi, Pfeffer, **:00**, pp. 165, 167. [Mediterranean; Orotava; Atlantic.]

Pterygioteuthis, H. Fischer, 1895.

P. giardi, H. Fischer, 1895.

Pterygioteuthis giardi, Hoyle, **:04**, pp. 39, 51, pls. vii., viii. [full description with figures, luminous organs; Eastern Pacific]: Chun, **:08** [amended diagnosis].

P. gemmata, Chun, **:08.** [S. Atlantic.]

Pterygioteuthis sp., Chun, **:03**, p. 72 [luminous organs]; **:04**, p. 243 [hectocotylised arm]; **:05**, p. 645 [male organs].

Pyroteuthis, Hoyle, **:04.**

P. margaritifera (Rüppell, 1844).

Enoploteuthis	*margaritifera*,	Ficalbi, **'99**, p. 81 [reprint of original description and figure].
Pterygioteuthis	,,	Pfeffer, **:00**, p. 166.
,,	,,	Hoyle, **:02** [luminous organs].
Enoploteuthis	,,	Lo Bianco, **:03** [young specimen figured].
Pyroteuthis	,,	Hoyle, **:04**, p. 42.

Octopodoteuthis, Rüppell, 1844.

Verania, Auctt.

O. sicula, Massy, **:07**, p. 381. [S. W. Ireland.]

Cucioteuthus, Steenstrup, 1882.

C. unguiculatus (Molina, 1782).

Cucioteuthis unguiculatus, Joubin, **'98a**, p. 149; **:01**, p. 51 [description of fragmentary specimens].

ARCHITEUTHIDÆ, Pfeffer, **:00**, p. 152.

Architeuthus, Steenstrup, 1856.[1]

A. princeps, Verrill, 1875.

Architeuthis princeps, Girard, **'92**, p. 214 [S. Miguel, Azores].

A. stocki (Kirk).

Steenstrupia stockii, Kirk, **'82**, p. 286, pl. 36.

[1] Marks indicating attacks on Cetacea; Thompson, **:01.**

TRACHELOTEUTHIDÆ, Pfeffer, :00, p. 152.

Tracheloteuthis, Steenstrup, 1881.

Verrilliola, Pfeffer, 1884, Steenstrup, '98.
Entomopsis, Rochebrune, 1884.

T. riisei, Steenstrup, 1881, '98.
T. riisei, Fowler, '97, p. 525 [Faeroe Channel].
,, Hoyle, :05a, p. 93, pl., figs. 1-5 [synonymy ; British area].
T. behni, Hoyle, :05a.

T. alicei (Joubin).
Entomopsis Alicei, Joubin, '99, p. 72 ; :01, p. 93, pl. xi. figs. 11, 12, pl. xii. figs. 8-12 [N. Atlantic].

T. velaini (Rochebrune, 1884).
Entomopsis Velaini, Joubin, '99, p. 72 ; :01, p. 91, pl. xi. fig. 13.

Brachioteuthis, Verrill, 1881.

This genus is almost certainly identical with *Tracheloteuthis*, Stp.; *see* Hoyle :04c, p. 20.

B. bowmani, Russell, :09, p. 449. [Faeroe Channel.]

BATHYTEUTHIDÆ, Pfeffer, :00, p. 152.

Bathyteuthis, Hoyle, 1885.

B. abyssicola, Hoyle, :04, p. 33, pl. i. fig. 2. [Gulf of Panama.]
Bathyteuthis sp., Chun, :03. [Structure of eyes.]

Ctenopteryx, Appellöf, 1890.

Sepioteuthis sicula, Rüppell (Vérany, '51, p. 75, pl. 27), is regarded by Pfeffer (:00, p. 172) as the type of the genus, all the other named species being synonymous with it: see Jatta, :04, p. 201, and Ashworth & Hoyle, :06, on this question.

C. fimbriatus, Appellöf, 1890.
C. cyprinoides, Joubin, 1894.
C. fimbriatus, Ashworth & Hoyle, :06.

C. nevroptera (Jatta, 1896).
Ctenopteryx siculus, Pfeffer, :00, p. 172 (*pars*).
,, *nevroptera*, Jatta, :04, p. 201.
,, ,, Ashworth & Hoyle, :06.

HISTIOTEUTHIDÆ, Verrill, 1881.

Histioteuthis, d'Orbigny, 1839.

H. ruppelli, Chun, :06. [Male organs.] [1]
H. bonelliana, Massy, :07, p. 381. [Off S.W. Ireland.] [1]

[1] There can be little doubt that these two species are identical, in which case the name *H. bonelliana* has priority.

Histiopsis, Hoyle, 1885.

This genus has almost certainly been based on young stages of *Histioteuthis;* see Hoyle, **:01a.**

H. atlantica, Hoyle, 1885.

Histiopsis atlantica, Lo Bianco, **:03,** p. 172, pl. viii. fig. 22 [young].

Calliteuthis, Verrill, 1880.

C. reversa, Verrill, 1880.

C. reversa, Chun, **:03,** p. 72 [phosphorescent organs]; Chun, **:06** [male organs].

Stigmatoteuthis, Pfeffer, :00, p. 170.

S. hoylei, (Goodrich, 1896).

Histiopsis Hoylei, Goodrich, **'96,** p. 15, pl. 4 figs. 62-71.

This form has been made by Pfeffer the type of a new genus, but I am not convinced of the necessity for such a step.

Meleagroteuthis, Pfeffer, :00, p. 170.

M. hoylei, Pfeffer, **:00,** p. 170. [Fonseca Bay; west coast of Central America.]

Meleagriteuthis Hoylei, Joubin, **:05,** p 64 [luminous organs].

Meleagroteuthis hoylei, Pfeffer, **:08a,** p. 292 [full description].

Dubioteuthis, Joubin, '99, :01.

D. physeteris, Joubin, **'99,** p. 73; **:01,** p. 102, pl. xv. figs. 8, 9, 10. [N. Atlantic.]

Ommastrephidæ, Gill, 1871.

For a discussion of the generic names to be used in this family see Hoyle, **:02a.**

Ommastrephes, d'Orbigny, 1835.

O. sagittatus (Lamarck, **:98,** p. 130).

Ommatostrephes todarus, Grieg, **'96,** p. 23 [occasional occurrence in numbers on Norwegian coast].

Ommastrephes sagittatus, M'Intosh, **:07** [large British specimen].

O. sagittatus, var. sloanei.

Ommastrephes Sloanii, Gray, **'49,** p. 61.

Todarodes pacificus, Joubin, **'97a** [Vladivostok].

Ommatostrephes sagittatus sloanei, Pfeffer, **:00,** p. 179.

Ommastrephes insignis, Gould, 1852.
Todarodes pacificus, Stp., **'80.** } (*fide* Pfeffer).
Ommastrephes gouldi, M'Coy, 1888.

,, ,, Brazier, **'92,** p. 17 [Victorian Water, S. Australia].

O. guernei (Joubin), 1895.
Tracheloteuthis Guernei, Joubin, 1895.
Ommastrephes ,, Joubin, **:01**, pp. 45, 46.
Ommatostrephes guernei, Pfeffer, **:00**, p. 176.

Symplectoteuthis, Pfeffer, :00, pp. 178, 180.

S. oualaniensis (Lesson, 1830).
Symplectoteuthis oualaniensis, Pfeffer, **:00**, p. 180.
Ommastrephes ,, Brazier, **'92**, p. 16 [Torres Strait, Great Barrier Reef, Nickol Bay].
Symplectoteuthis oualaniensis, Hoyle, **:04**, p. 32, fig. F [Cocos Is., E. Pacific; funnel groove]; Hoyle, **:05**, p. 982 [Laccadive Is.].

Sthenoteuthis, Verrill, 1880.

S. bartrami (Lesueur, 1821).
Ommatostrephes Caroli, Furtado, 1887 (*fide* Pfeffer).
,, *bartramii*, v. *sinuosus*, Lönnberg, **'97a**, p. 701 [Teneriffe].
Stenoteuthis bartrami, Pfeffer, **:00**, p. 180.
Ommastrephes Bartrami, Joubin, **:03a**.

S. megaptera (Verrill, 1878).[1]
Stenoteuthis megaptera ?, Albert, Prince of Monaco, **:03**, p. 213 [N. Atlantic].

S. pteropus (Steenstrup, 1856).
Ommastrephes pteropus, Goodrich, **'92**
Sthenoteuthis ,, Nichols, **:05** [Co. Clare, Ireland].

Dosidicus, Steenstrup, 1857.

D. gigas (d'Orbigny, 1835).
Ommastrephes gigas, d'Orbigny, 1835.
Dosidicus eschrichti, Steenstrup, 1857.
,, *steenstrupii*, Pfeffer, 1884.
Martialia hyadesi, Rochebrune & Mabille, 1889.
} *fide* Pfeffer.
Ommastrephes gigas, Brazier, **'92**, p. 16 [N. Queensland, New South Wales, Lord Howe Is.]; Plate, **'97**.
Dosidicus ,, Steinhaus, **:03** [coast of Chili; very large example].

Illex, Steenstrup, '80.

I. illecebrosus (Lesueur, 1821): Chun, **:05**, p. 649. [Male organs.]

Hyaloteuthis, Gray, 1849.

H. pelagicus (Bosc, 1802). [This species and genus are reinstated by Pfeffer, **:00**, p. 180.]

[1] Pfeffer regards this as a synonym of the next species, which may very likely be the case.

Todaropsis, Girard, 1890.

T. eblanæ (Ball, 1841).

Todaropsis Veranyi, Girard, 1890.

,, *eblanæ*, Hoyle, :03, [description of type specimen].

Rhynchoteuthis, Chun (*nec* d'Orbigny).[1]

Rhynchoteuthis sp., Chun, :03a, p. 716.

Poulpe (jeune âge)? Eydoux & Souleyet, Voy. "Bonite," p. 17, pl. i.

R. chuni, Hoyle, :04, p. 32, fig. G. [Tropical Pacific.]

This genus (the name of which was preoccupied by d'Orbigny) is probably based on the larval stages of an Ommastrephid.

Cirrobrachium, Hoyle, :04.

C. filiferum, Hoyle, :04, p. 28. [N. of Marquesas Is.]

Professor Chun has suggested to me that the filaments springing from the arms of this specimen were originally ribs strengthening a web attached to the side of the arm: I think this may very likely be the case, and if so the genus would find its place in the Ommastrephidæ.

Chiroteuthidæ, Gray, 1849.[2]

Chiroteuthis, d'Orbigny, 1839.

Ficalbi ('99a) has maintained that *Doratopsis vermicularis* is the young of a species of this genus, but this position is combated by Pfeffer (:00): it has been reiterated by Jatta, :04, p. 193, and quite recently supported by Chun, :08. I do not think the question can yet be regarded as settled; *see* Ficalbi, :02, p. 37.

C. imperator, Chun, :08. [Nias, Sumatra; Sagami Bay, Japan.]

C. macrosoma, Goodrich, 1896.

Cheiroteuthis macrosoma, Nishikawa, :06 [Japan].

C. veranyi (Férussac, 1835).

C. veranyi, Chun, :03, p. 74 [luminous organs].

Chiroteuthopsis, Pfeffer, :00, p. 184.

It appears to me very doubtful whether this genus is well founded; Chun, :08, regards it as a synonym of *Mastigoteuthis*.

C. grimaldii, Joubin, 1895, :03, p. 100. [55 miles N.N.W. of Fayal, 1900 metres.]

C. talismani, Fischer, H., and L. Joubin, :06, p. 205; :07, p. 342, pl. xxv. figs. 1-4. [S. of the Azores.]

[1] Pfeffer, 08, p. 88, proposes the name *Rhynchoteuthion* as a substitute.

[2] Chun, :08, divides this into three subfamilies—Mastigoteuthinæ, Chiroteuthinæ, Grimalditeuthinæ.

Ouroteuthis, P. Fischer, *in*, Filhol, **'85a**, p. 175.

O. megaptera, Fischer, *in* Filhol, **'85a**, p. 175.

In the year 1885 the late Dr Paul Fischer showed me some cephalopods to which he had attached the name *Ouroteuthis*, and this name has since appeared in print. Speaking from memory, I believe these specimens were those referred to *Chiroteuthopsis* by H. Fischer and Joubin, **:07**, ; in any case the name *Ouroteuthis megaptera*, being uncharacterised, has no validity. It is mentioned here merely as a warning to prevent its being used again.

Doratopsis, de Rochebrune, 1884.

On the question whether this genus is merely a larval form of *Chiroteuthis* see above.

D. sagitta, Chun, **:08.** [Cape Verde and S. Indian Ocean.]
D. exophthalmica, Chun, **:08.** [Madeira and S. Indian Ocean.]
D. lippula, Chun, **:08.** [Benguela current, S.E. Africa.]

Mastigoteuthis, Verrill, 1881.

M. cordiformis, Chun, **:08.** [Nias Channel, Sumatra.]
M. dentata, Hoyle, **:04**, p. 34, pl. vi. figs. 8-11. [Off Galapagos Is.; off Cape Mala, Gulf of Panama.]
M. flammea, Chun, **:08.** [Guinea current.]
M. glaucopis, Chun, **:08** (*glaukopis*). [E. African coast.]
M. levimana, Lönnberg, **'97**, p. 605 [Lat. 43° N., long. 24° W.]

GRIMALDITEUTHIDÆ, Pfeffer, **:00**, pp. 154, 187.

Grimalditeuthis, Joubin, **'98.**

G. richardi, Joubin, **'98, :01**, p. 79, pl. iv. figs. 1, 2, pl. v. figs. 1-13, pl. x. figs. 1, 2.

This is almost certainly synonymous with *Chiroteuthis bonplandi* (Vérany), which has been referred to the same genus: see Pfeffer, **:00**, p. 188.

CRANCHIIDÆ, Gray, 1849 (*em.*).

Cranchiæformes, Steenstrup, 1861.

Cranchia, Leach, 1817.

C scabra, Leach, 1817.

C. scabra, Hoyle, **:04**, p. 43. pl. x. fig. 11 [figure and description of arms and tentacles].

C megalops, Prosch, 1847.

The generic name *Owenia*, proposed as a subgenus by Prosch, cannot be used for this form, because, as Steenstrup ('81, pp. 20-23) has pointed out, the characters on which it was based belong not to a *Cranchia* at all, but to some young specimens of *Gonatus fabricii* which had become associated with it. I do not think it needful to propose another generic name, for the specimen is immature, and probably near *C. scabra*.

Liocranchia, Pfeffer, 1884.

L. reinhardti (Steenstrup), Pfeffer, :00, p. 194; Chun, :06a, p. 84.

Cranchia reinhardtii, Loennberg, '97, p. 609 [hectocotylised arm].

L. valdiviæ, Chun, :06a, p. 84.

Leachia, Lesueur, 1821.

L. cyclura, Lesueur, 1821.

L. cyclura, Richard, :03, p. 75 [Atlantic; numerous dead males]; Joubin, :05 [luminous organs].

Zygocranchia, n.n.[1]

Zygænopsis, Rochebrune, 1884; Pfeffer, :00, p. 193; Chun, :06a, p. 84. *Pyrgopsis*, Rochebrune, 1884.

Z. zygæna (Vérany, 1851).

Hensenioteuthis, Pfeffer, :00, p. 189.

H. joubini, Pfeffer, :00, p. 193. [Atlantic; undescribed.]

Taonidium, Pfeffer, :00, pp. 189, 192.

T. pfefferi, Russell, :09, p. 451. [Faeroe Channel.]

T. suhmi (Lankester, 1884).

Pfeffer (:00, pp. 189, 192) has made this form the type of a new genus *Taonidium*, which Chun regards as synonymous with *Galiteuthis* (*vide infra*).

Taonius suhmi, Jatta, '99, p. 27, pl. i. fig. 25 [between Callao and the Galapagos Is.; critical remarks].

Galiteuthis, Joubin, '98c.

G. armata, Joubin, '98c. [Mediterranean.]

Chun, :06a, p. 86, identifies the genus with *Taonidium*, Pfeffer, :00; if this be correct Joubin's name has priority, but the

[1] The name *Zygænopsis* was used by Felder in 1874 for a genus of Lepidoptera, *Zool. Record*, 1874, p. 400. Pfeffer (:00) regards as synonyms *Pyrgopsis rhynchophorus*, Rochebrune, *Loligopsis schneehageni*, Pfr., and *Taonius richardi*, Joubin.

evidence has not yet been published. The genus was made by Joubin the type of a family Cranchionychiæ, a name which does not conform to the International rules for the construction of family names.

Taonius, Steenstrup, 1861.

T. pavo (Lesueur, 1821).
Taonius pavo, Richard, **:03**, p. 77; Joubin, **:03** [N. Atlantic; surface].

Desmoteuthis, Verrill, 1881.
Megalocranchia, Pfeffer, 1884.

D. abyssicola (Goodrich, 1896).
Taonius abyssicola, Goodrich, **'96**, p. 17, pl. v. figs. 72-80.
Desmoteuthis ,, Pfeffer, **:00**, p. 192.

D. hyperboreus (Steenstrup, 1861).

D. maxima (Pfeffer, 1884).

Pyrgopsis, Rochebrune, 1884.

Pfeffer (**:00**, p. 193) regards this as a synonym of *Zygœnopsis*, Rochebrune (vide *Zygocranchia* supra).

Helicocranchia, Massy, **:07**.

H. pfefferi, Massy, **:07**, p. 382. [Off S.W. Ireland; 350 fathoms.]

Corynomma, Chun, **:06a**.

C. speculator, Chun, **:06a**, p. 85. [Atlantic and Indian Oceans.]

Crystalloteuthis, Chun, **:06a**.

C. glacialis, Chun, **:06a**, p. 85. [Antarctic Ocean.]

Sandalops, Chun, **:06a**.

S. melancholicus, Chun, **:06a**, p. 86. [Atlantic Ocean.]

Toxeuma, Chun, **:06a**.

T. belone, Chun, **:06a**, p. 86. [Indian Ocean.]

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B. lyromma, Chun, **:06a**, p. 86. [Atlantic Ocean.]

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INDEX.

This Index contains, in the first place, all the generic and specific names in the "Catalogue of Recent Cephalopoda" and its two supplements; page numbers preceded by i., ii., refer to the first and second supplements respectively; those with no prefix to the original Catalogue. It includes also a large number of synonyms, with an indication, so far as possible, of their valid equivalents; in many cases it is impossible to ascertain with any certainty the species which the older writers had before them, and the only useful purpose which can be served by such a list is as a warning to prevent their being used again. The list does not, however, make any pretensions to completeness. When a specific name has been used in several genera it is arranged according to the first letter of the latter without regard to their gender, thus *rugosus* (*Polypus*) would precede *rugosa* (*Sepia*), and for indexing purposes I have ignored the distinction between genitives ending in *i* or *ii*, though when I quote another author I give the word in the form used by him.

Synonyms are in Italics.

[1] This "species" furnishes a curious instance of the propagation of error. It is based on a figure given by Borlase ("Nat. Hist. Cornwall," pl. 25, fig. 27, 1758). At the lower end of the drawing are the words "by Scale AA," referring to a scale of measurement on the plate. It has been taken to be the name of the species, and in the amended form "biscale" appears in the synonymy of *Loligo vulgaris* in d'Orbigny, '45, p. 337.

XXV. *Some Medusæ and Ctenophores from the Firth of Forth.*

By Wm. Evans, F.R.S.E., and J. H. Ashworth, D.Sc.

(Read 21st December 1908.)

On 27th June last—which was an ideal midsummer day, being calm, bright, and warm—we went to Dunbar for the purpose of collecting marine invertebrates. On our arrival at the harbour we found, swimming alongside the quay and among the fishing boats, swarms of small medusæ and ctenophores, a considerable number of which we captured by the aid of net and bucket. The collection was noteworthy for the beauty of form and colour of the various organisms, especially striking being the constant play of rainbow colours along the combs of the ctenophores. With the exception of an extremely fragile bilobate ctenophore, afterwards identified as *Bolina infundibulum* (Fabr.), specimens of the different species obtained were preserved in formalin (6%) for further examination. It was, however, found impossible to fix any specimen of *Bolina*. Various strengths of formalin were used, but with the invariable result that dissolution of the specimen took place within a few seconds of the application of the fixative. On a subsequent occasion, a chrom-osmic mixture (chromic acid 1%, 100 parts, osmic acid 1%, 2 parts) in large volume was used with scarcely better results. Similar failure has, it appears, been the experience of others who have attempted the preservation of this beautiful ctenophore.

With the view of supplementing the observations made on 27th June, one of us (W. E.) revisited the harbour at Dunbar on a number of occasions during the succeeding six months, and obtained a few additional species, including the interesting medusa *Tima bairdii* (Johnst.), which he has also found during the present month (December), along with an *Aequorea,* in the harbour at Burntisland.

To Edward Forbes, Sir John Dalyell, and Strethill Wright we are indebted for a few early records of medusæ and ctenophores from the Firth of Forth, but very little has since been added to our knowledge of the species occurring

in the Firth.[1] Only a dozen, including one or two obtained by the German North Sea Expedition of 1872, are given in Leslie & Herdman's catalogue of Forth marine invertebrates (1881). In the Fishery Board's tables of observations made on the "Garland," ctenophores and "small medusæ" are often entered, but the species seem seldom to have been determined.

The paucity of existing records must be our excuse for bringing this slight contribution to the subject before the Society. For the identification of several of the medusæ we have to thank Mr Edward T. Browne, B.A., University College, London, who has kindly examined a set of our specimens, and also enlarged our knowledge of the literature. In any study of the Medusæ and Ctenophora of the Firth of Forth, Prof. M'Intosh's numerous records from the adjoining area of St Andrews Bay[2] ought to be consulted.

The synonymy given in the following notes is confined to references to Forth records.

MEDUSAE.

HYDROMEDUSAE.

Margelis britannica (Forbes).

Bougainvillia britannica, Forbes's "Monograph of the British Naked-eyed Medusæ," 1848; and Leslie & Herdman's "Invertebrate Fauna of the Firth of Forth," 1881.

This "beautiful little animated bubble," as Edward Forbes so happily called it, occurred in Dunbar Harbour on the 2nd, and again on the 11th of July (1908)—a few specimens being obtained on each occasion. The width of the largest is 8 mm.

Forbes met with *M. britannica* at the entrance of the Firth of Forth prior to 1848, and Leslie & Herdman took it (in surface net) east of Inchkeith in the summer of 1880. Prof. M'Intosh has found it frequently in the tow-net in St

[1] See Evans on "Our Present Knowledge of the Fauna of the Forth Area" in the first part of this volume.

[2] In *Ann. and Mag. Nat. Hist.*, *Reports Fish. Bd. Scotl.*, *etc.*

Andrews Bay,[1] and mentions *Margelis ramosa*, Agass., which occurs in the Forth,[2] as its hydroid.

Sarsia tubulosa (Sars).

Although well known in the adjoining Bay of St Andrews, this graceful little medusa does not appear to have been previously recorded from Forth waters. It was abundant in the harbour at Dunbar on 27th June last, swimming about in quite an active manner, with the long bluish manubrium streaming from the pulsating pellucid bell. Our specimens range from 7 mm. to 11 mm. in long diameter.

The hydroid of *Sarsia tubulosa* is believed to be a *Syncoryne* —*S decipiens*, Duj., according to Prof. M'Intosh, which is stated to have been taken in the Firth of Forth by Strethill Wright.[3]

Melicertidium octocostatum (Sars).

Stomobrachium octocostatum, Strethill Wright's "Observations on British Zoophytes," 1863[4]; and Leslie & Herdman's Catalogue (1881).

A few specimens were taken in Dunbar Harbour on 3rd and 5th October, the weather at the time being exceptionally fine and warm. Three specimens preserved are of the same size, namely, about 6 mm. across.

Strethill Wright (*l.c.*) says this medusa "is occasionally found in the Firth of Forth, in the neighbourhood of Queensferry and Granton." This would seem to be the only previous record from the Forth. At St Andrews, where it is common (M'Intosh), it has been noted in January, August, October (none mature), and December when it reached a diameter of half an inch. We are not aware that its connection with any hydroid form has yet been established.

Tiaropsis multicirrata (Sars).

This was plentiful in Dunbar Harbour on June 27th, and it was again observed there on July 2nd. In half a dozen

[1] "Notes from the St Andrews Marine Laboratory" (*Ann. and Mag. Nat. Hist.*, ser. 6, vol. v., 1890, p. 296).

[2] Leslie and Herdman, "Invertebrate Fauna of Firth of Forth," 1881, p. 11.

[3] Hincks, 'British Hydroid Zoophytes,' 1868, p. 57.

[4] *Proc. Roy. Phys. Soc.*, vol. iii. p. 42.

specimens measured, the width ranges from 10 mm. to 19 mm. The largest has 268 tentacles, which seems to be about the average number. In other cases we make out 256, 260, 268, 272, and 272. Among the series of tentacles there are 8 sense-organs—two in each quadrant at points rather nearer the adjacent canals than to each other.

Tiaropsis multicirrata has been recorded from Plymouth,[1] and Falmouth in the south, and by Mr E. T. Browne from the Isle of Man, Valencia Harbour, and the Firth of Clyde[2]; but we have not seen any record from the east coast of Britain. Sars described it from Norwegian specimens, and Hartlaub, who has obtained it at Heligoland,[3] quotes Metschnikoff that its hydroid is allied to *Cuspidella*.

Mitrocomella polydiademata (Romanes).

Several examples of this medusa were obtained in Dunbar Harbour on 27th June; but, not being readily distinguished in the water from small examples of the next species, we cannot say whether it was present in any abundance. Width of umbrella in largest specimen 8·5 mm.

M. polydiademata was described by Romanes in 1876, in the Journal of the Linnean Society,[4] from specimens taken in the Cromarty Firth; and it has since been recorded by Mr Browne from the Isle of Man, Bergen, and the Clyde,[5] but we have seen no further record from the east of Scotland.

Eutonina socialis, Hartlaub.

A Thaumantias-like medusa, which Mr Browne has identified for us as the *Eutonina socialis* of Hartlaub, was present in abundance in Dunbar Harbour on 27th June; and again, but in less numbers, on 2nd and 11th July. On 8th August all trace of them was gone. The diameter of the specimens

[1] *Journ. Mar. Biol. Assoc.*, n.s., vol. vii., No. 2 (1904), p. 199.

[2] *Proc. Roy. Soc. Edin.*, vol. xxv. pt. ix. (1905), p. 773.

[3] *Wissensch. Meeresuntersuchungen . . . deutsch. Meere, etc.*, N. F., Bd. 1 1894), p. 193.

[4] Vol. xii. (Zool.), p. 525; fig. in vol. xiii., pl. xv.

[5] *Proc. Roy. Soc. Ed.*, vol. xxv. pp. 767-769, 1905.

preserved ranges from 15 mm. to 25 mm.,[1] and the number of tentacles is about 160.

Eutonina socialis was named and described by Dr Hartlaub in 1897[2] from specimens collected at Heligoland, but prior to that it had been obtained at St Andrews, and well figured though not named, by Prof. M'Intosh.[3] Hartlaub has seen one of the St Andrews specimens, and states it belongs to his species.[4] It does not appear to have been recognised outside the North Sea area. According to Hartlaub its hydroid is a *Campanulina*.

Tima bairdii (Johnst.).

Medusa (*Tima*) sp., Dalyell's "Rare and Remarkable Animals of Scotland," vol. ii. (1848), p. 250, pl. lii. fig. 5.

Tima bairdii, Forbes's Monograph (1848); and Leslie & Herdman's Catalogue (1881).

On December 5th this interesting and beautiful medusa was present in hundreds in both the principal and the old harbours at Dunbar, swimming at or near the surface in every sheltered corner. Although mild, the day was dull and stormy. The majority of the specimens were mature, or nearly so, averaging about 35 mm. in width (the largest taken was about 50 mm.), but immature ones from 15 to 25 mm. were not uncommon. A few, mostly immature, were met with in Burntisland Harbour on 12th and 14th December, and on 21st they were there in great profusion, many being full grown (50-60 mm.), and bearing ripe gonads. On a few of them the curious *Hyperia galba* was found, but both here and at Dunbar another crustacean, *Metopa alderi* (Bate), was much more common upon them.

Half a dozen from Dunbar were kept alive in a glass jar for about a week. Swimming was effected by contractions of the bell (and tentacles) at the rate of about 40 per minute. On the jar being placed in the dark and sharply struck or

[1] Mature specimens since obtained (June 1909) at Burntisland attain a diameter of as much as 35 mm.

[2] *Wissensch. Meeresuntersuch. . . . deutsch. Meere, etc.*, N. F., Bd. ii. (1897), p. 506.

[3] *7th Rpt.* (*for* 1888) *Fish. Bd. Scot.*, pt. iii. p. 282, pl. v. figs. 6-9; and *Ann. and Mag. Nat. Hist.*, 6 ser. v. (1890), p. 300.

[4] *Op. cit.*, Bd. v., Abteil. Helgoland, Heft 2 (1904), p. 103.

shaken, the medusæ emitted flashes of pale greenish-white light. During the night, if left in the dark, they seemed to remain motionless at the bottom of the jar, but soon began to pulsate and swim about when brought into a lighted sitting-room. While the stimulation was probably due primarily to light, the higher temperature of the room may also have been a factor.

Normally the number of tentacles is 16, as observed by Forbes; but frequently they are not all developed, one or more being then represented by a minute bulb—in one case as many as seven were thus reduced. Johnston's original specimen had but 13 tentacles. Of 33 cases noted by us, nine had 16 tentacles, nine 15, five 14, six 13, two 11, one (small) 10, and one 9. The presence of an extra bulb in one of the normal specimens is the only indication we have seen of the production of more than 16 tentacles. In life, the tentacles were of a delicate rose-pink colour, which left them, however, very soon after the application of the formalin.

Under the name of *Dianæa bairdii* this medusa was described by Dr George Johnston from a specimen found floating on the surface of the water in Berwick Bay on 27th Sept. 1832[1]; and, "during the winter of 1839," Forbes (*l.c.*) met with it in the harbour at Burntisland, and also at St Andrews, where it has since been taken on many occasions (M'Intosh). Dalyell's figure (*l.c.*) of a medusa he received from a Cellardyke fisherman in the month of December, from the neighbourhood of the Isle of May, clearly represents a *Tima bairdii.* It is a better figure than Forbes's, which is poor. This is essentially a winter medusa, reaching the spawning state from November to January.[2] The hydroid stock from which it springs is not known, but probably it is some Campanulariid, as in the case of the American form mentioned by Louis Agassiz. In British waters it appears, as yet, to have been recorded only from the east coast. On the opposite side of the North Sea it has been taken at Heligoland by Hartlaub.

[1] *Loudon's Mag. Nat. Hist.*, vol. vi. (1833), p. 320, pl. 41.

[2] On 16th March 1909, large numbers were stranded on the beach east of North Berwick.

Aequorea norvegica, Browne.

? *Æquoria*[1] *vitrina*, Strethill Wright, *Proc. Roy. Phys. Soc. Ed.*, vol. ii. (1863), p. 316.

In January last Prof. E. A. Schäfer found an *Aequorea* on the beach at North Berwick, and to-day (21st December) one of us (W. E.) had the good fortune to see eleven, seven of which he captured, swimming near the surface of the water at the mouth of Burntisland Harbour. The North Berwick example, of which Prof. Schäfer has kindly shown us a portion he preserved, would have a diameter of 4 to $4\frac{1}{2}$ inches. Our specimens range from 3 to 7 inches.[2] In one of the largest and most perfect (170 mm. in width), bearing ripe gonads, the number of radial canals is 73, the marginal tentacles about 450, and the oral lips 46. Another large specimen has 75 canals, while a rather smaller one (155 mm.) seems to have about 100. The large ribbon-like gonads are of a creamy-white colour, as are also the canals and tentacles. The "jelly," which is of no great thickness (one inch at the centre of a large specimen), is perfectly colourless, and glass-like in its transparency.

Æquorids—the giants among Leptomedusæ—are occasionally met with on the south and west coasts of our islands; but, with the probable exception of Strethill Wright's specimens, we are not aware of any previous record for the east coast of Scotland.

In the 1st vol. of the Wernerian Society's *Memoirs* (1811, p. 558), "*Medusa æquorea*" is mentioned by Prof. Jameson as an inhabitant of the Orkney and Shetland seas. In August 1850, Edward Forbes[3] observed a number of individuals of an *Aequorea*, for which he adopted the name of *Æ. forskalea*, Peron, in the Minch, between Skye and the Outer Hebrides. Some years later, namely in 1861, in a paper on the reproduction of *Aequorea*, the following statement was made (*l.c.*) by Strethill Wright:—"In the beginning of this month (Nov.) Mr Fulton sent me two living specimens of *Æquoria vitrina*, one about three inches in diameter,

[1] This is the spelling used by Wright throughout his paper.

[2] The diameters are approximately 3, 4, $4\frac{3}{4}$, $5\frac{1}{2}$, $6\frac{1}{4}$, $6\frac{1}{2}$, and 7 inches.

[3] *Proc. Zool. Soc. Lond.*, vol. xix. (1851), p. 272.

the other about six inches and a half. The number of lips of the latter was about forty, the radiating canals, each having a long ovisac, about eighty, and the marginal tentacles, by estimation, four hundred." Unfortunately Dr Wright does not say where the specimens were captured, but seeing they were received alive, and that earlier in the volume (p. 193) he designates Mr Fulton as "of Granton Pier," the probability is they were taken in the Firth of Forth. From the eggs, Campanularian polyps developed.

The determination of Æquorids being a matter of very considerable difficulty, we have sent one of the Burntisland specimens to Mr E. T. Browne, who has come to the conclusion that it must be referred to his *Aequorea norvegica*, described in 1903 from a Norwegian specimen.[1] Mr Browne's species is apparently very closely related to *Aequorea vitrina*, Gosse (1853).

SCYPHOMEDUSAE.

Cyanea capillata (Linn.).

Cyanea capillata, Leslie & Herdman's Catalogue, p. 61.

A few small examples (2-4 inches in diameter) were observed in Dunbar Harbour on 27th June and 2nd July; one, 6 inches across, on 11th July; and one, 12 inches, on 8th August. On 5th October two large dead ones were floating in the harbour. At the fishing-grounds they were numerous in July and August, many being entangled in the nets. During some days of high wind from the north in the last week of August great numbers, mostly of large size, were cast ashore between Aberlady and North Berwick.

Cyanea capillata, it is scarcely necessary to add, is the "stinging jelly-fish," and is only too well known in the lower reaches of the Firth, where it is an annual source of annoyance to the fisherman.

Aurelia aurita (Linn.).

Aurelia aurita, Leslie & Herdman's Catalogue, p. 61.

On 3rd, and again on 5th Oct., about a score were seen in Dunbar Harbour, their width ranging from 3 to 6 inches; and

[1] *Bergens Museums Aarbog*, 1903, No. 4, p. 19.

on 5th Oct., one about 4 inches in diameter was found in a rock-pool at North Berwick. Though usually common enough, this species appears to have been rather scarce in the Firth this year, and the presence of these small examples so late as October, suggests the possibility of them hibernating in deep water and reappearing in the spring. Fishermen at Dunbar assured us that the trawlers occasionally get "jelly-fish" in their trawls during winter, and in the 12th Report of the Fishery Board for Scotland (part iii., p. 49), it is recorded that a few *Aurelia aurita* were brought up in the "Garland's" trawl-net near the Isle of May on 18th Jany. 1893. "It is worthy of note," writes Prof. M'Intosh, with reference to *Cyanea* and *Aurelia* in one of his papers from the St Andrews Laboratory, "that once in January a large example [of *Cyanea ?*] was procured by the trawl in deep water and at a considerable distance from the shore—a solitary survivor of the hosts of autumn." *Hyperia galba* was plentiful on these Dunbar *Aureliae.*

CTENOPHORA.

Pleurobrachia pileus (Fab.).

Pleurobrachia pileus, Fleming's *British Animals,* 1828, p. 504.

Cydippe pomiformis, Forbes and J. Goodsir's paper "On the Ciliograda of the British Seas," *Brit. Assoc. Rep.* 1839, Miscel. comm., p. 85.

Beroë pileus, Dalyell's *Rare and Remarkable Animals of Scotland,* vol. ii., 1848, p. 257.

Pleurobrachia pileus, Schulze in Rep. German North Sea Expedition of 1872, *Jahresb. d. Comm. z. Untersuch. d. deutsch. Meere in Kiel,* III., 1873, p. 139; Leslie & Herdman's Catalogue; Fish. Bd. Reps.; and Evans in present vol., p. 16.

Two specimens of this pretty little ctenophore were captured in Dunbar Harbour on 2nd July, and on the 11th it was common; a few were also taken there on 3rd Oct. Their length ranged from 10 to 14 mm. On 14th Dec. the finest example we have seen was secured in Burntisland Harbour—its length is 30 mm. Vanhöffen, in "Nordisches Plankton" (xi., 1903), puts the maximum at 25 mm. From the Rev. J. Waterston we received a small specimen (about 5 mm.) taken near Inchcolm early in June.

P. pileus is a common species in the Firth of Forth,

whence it has been recorded by Fleming, Forbes and Goodsir, Dalyell, and others, as cited above. Prof. M'Intosh, in his Notes from St Andrews Bay, remarks that, while the finest examples are to be found in mid-winter, at no period is the water devoid of them, and throughout the greater part of the year small forms are mingled with the larger.

Bolina infundibulum (Fab.).

? *Beroë bilobata*, Dalyell, *op. cit.*, ii., 1848, p. 254.

Perhaps the most interesting species met with is the fine ctenophore, referred to on page 300, which we unhesitatingly refer to the *Beroë* (*Bolina*) *infundibulum*, Fab., as understood by Chun[1] and Vanhöffen.[2] In Dunbar Harbour on 27th June it was very plentiful—we must have seen not far short of a thousand. The sight was one not readily to be forgotten. On 2nd July it was equally abundant, and on the 11th only a little less so; but on subsequent visits in Aug., September, Oct., and Dec. (5th) none were to be seen. On 12th, 14th, and 21st December, however, a similar, though not so large, shoal was met with at Burntisland Harbour. Many examples were captured at both localities; but, as already mentioned, we were unable to preserve any of them in a serviceable condition. The Dunbar examples ranged from $\frac{3}{4}$ of an inch to $3\frac{1}{4}$ inches in length; at Burntisland they were on the average rather larger, many reaching a length of 3-4 inches, while one was no less than $5\frac{1}{4}$ inches (130 mm.). Some discharged ova in our jars.

Owing to inadequate descriptions, and the difficulty of preserving types, this species is cumbered with a considerable synonymy. According to Chun (*l.c.*) it is the *Mnemia norvegica* of Sars, the *Bolina hibernica* of Patterson, the *Alcinoë smithii* of Forbes and Goodsir—under which names it has been recorded from the west of Scotland,[3] and Ireland —and the *Beroë bilobata* of Dalyell, which was probably obtained from the Forth although no locality is given.

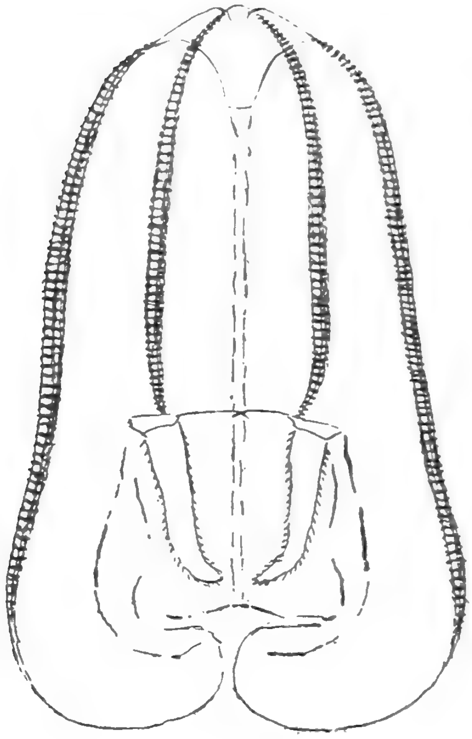
[1] *Die Ctenophoren der Plankton-Expedition*, 1898.

[2] *Nordisches Plankton*, xi., Ctenophoren, 1903.

[3] An early record (and fig.) of "*Bolina hibernica*" from Whiting Bay, Arran, will be found in Landsborough's 'Excursions to Arran,' 1847, pp. 322 and 326.

Browne records *B. infundibulum* from the Clyde,[1] and it is reported from the south coast of England; but, though known to occur in the North Sea, we have seen no certain records from the east coast of Scotland, unless the ctenophore recorded by Prof. M'Intosh from St Andrews Bay,[2] under the name of *Lesueuria vitræa*, M-Edw., was the present species.

Owing to the extreme delicacy of this form it was no easy matter to get uninjured examples into our jars, where at best their life was of short duration. Of a dozen brought home alive none survived the night. In the dark they emitted a pale phosphorescent light when the jar containing them was suddenly shaken or struck. The accompanying figure, drawn from a Dunbar example, represents the creature broadside on, *i.e.*, viewed in the transverse plane. Being in the form of a laterally flattened cone, the outline is much narrower (little more than half) when seen in the sagittal plane, *i.e.*, at right angles to the aspect here shown (see the figures in Vanhöffen's paper). The jelly is very soft, perfectly transparent, and colourless. *Hyperia galba* was found on one or two specimens.



Bolina infundibulum (Fab.).
A medium-sized specimen sketched from life.

Beroë cucumis, Fab.

Beroë ovata, Schulze's "Coelenteraten" collected by the German North Sea Expedition of 1872 (*l.c.*); and Pearcey, in *Trans. Nat. Hist. Soc. Glasg.*, n.s., vi. pt. 2, 1902, p. 228.

Idyia ovata, Leslie & Herdman's Catalogue.

Beroë cucumis, J. Arthur Thomson in Pollock's "*Dictionary of the Forth*," 1891, p. 156; and Evans (*l.c.*).

This common species was present in Dunbar Harbour on

[1] *Proc. Roy. Soc. Edin.*, xxv., p. 785, 1905.

[2] *Ann. and Mag. Nat. Hist.*, Dec. 1888, p. 464, and Jany. 1890, p. 46; also 7*th* (1888) *Rept. Fish. Bd. Scotl.*, 1889, p. 273.

27th June, 2nd July, and 11th July, being quite numerous on the last two dates, and of various sizes from $\frac{3}{4}$ of an inch to as much as $4\frac{1}{2}$ inches (2-3 on the average) in length. Some were shedding ova. During December (12th, 14th, and 23rd) *Beroë* was also abundant in Burntisland Harbour, the length ranging from about 1 inch to $3\frac{1}{2}$ inches. Colour pale pink.

In this area the specific names *ovata* and *cucumis* have doubtless been applied to the same form, but it would seem that they really represent two different species. In *B. cucumis,* Fab., according to Chun (*l.c.*), the proliferations of the meridional vessels which are situated on the stomach-wall, are not in communication with the stomach vessels, while they are in *B. ovata,* Bosc., from the Mediterranean. Our specimens conform in this as well as in other respects to the description of *B. cucumis.*

Note.—Besides a series of preserved specimens of the species mentioned in the paper, there were exhibited at the meeting living examples of *Tima bairdii, Aequorea norvegica, Bolina infundibulum,* and *Beroë cucumis* captured at Burntisland that day.

A *B* *C*

FIG. 1.—EXPLANATION.

A. The humerus of a woman of 50. To show the extraordinary prominence of the deltoid eminence. The woman's history is known. In early life she was a lady's-maid, and later she was bed-ridden, and at no time was she hard worked.

B. The humerus of a middle-aged man.

C. The humerus of a strong young man.

The deltoid impression is least strongly marked in the bone of the most muscular individual; most strongly marked in the bone of the least muscular.

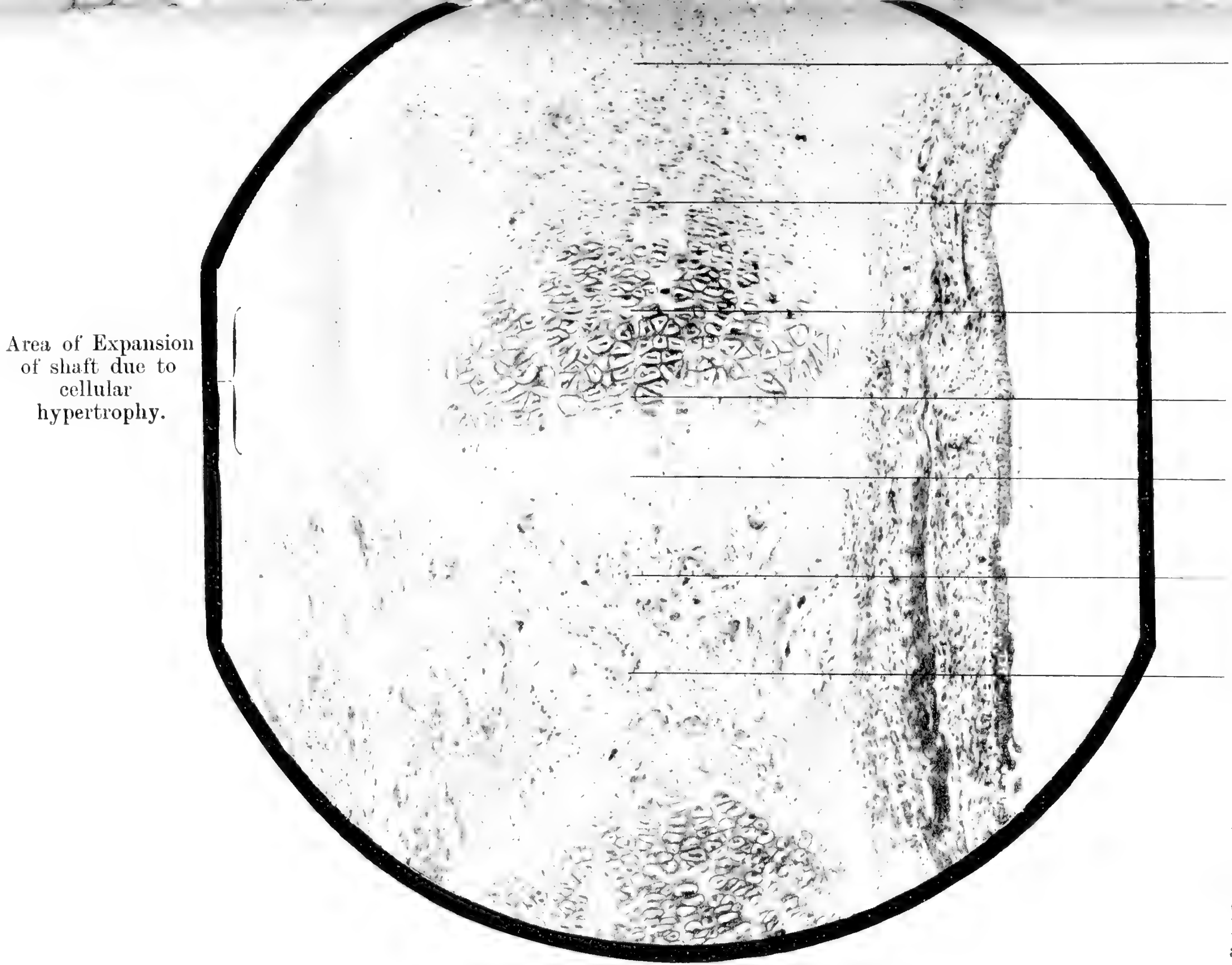


FIG. 2.

Microphotograph of the centre of ossification in a human fœtal long bone. The arrangement of the cells in the areas of disintegration, surfeit, and hypertrophy is in radiating columns. The more active the cell hypertrophy the more marked is this arrangement.

JOURNAL OF PROCEEDINGS.

SESSION CXXXVI.

Monday, 22nd October 1906.—Wm. Evans, Esq., F.R.S.E., President, in the Chair.

The retiring President delivered an address on "Our Present Knowledge of the Fauna of the Forth Area."

Monday, 26th November 1906.—Wm. Evans, Esq., F.R.S.E., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society:—R. B. Thomson, Esq., M.B., Ch.B.

The following Office-Bearers for the Session were elected:

President—Professor J. Graham Kerr, M.A., F.R.S.E.

Vice-Presidents—W. Eagle Clarke, F.L.S., F.R.S.E.; W. S. Bruce, F.R.S.G.S., F.R.S.E.; D. Waterston, M.D., F.R.C.S.E., F.R.S.E.

Secretary—O. Charnock Bradley, M.D., D.Sc., F.R.S.E.

Assistant-Secretary—J. H. Ashworth, D.Sc.

Treasurer—W. A. Middleton, C.A.

Librarian—T. N. Johnston, M.B., C.M., F.R.S E

Councillors—F. H. A. Marshall, B.A., D.Sc., F.R.S.E.; Percy H. Grimshaw, F.E.S.; Sir T. D. Gibson Carmichael, Bart.; Professor T. Hudson Beare, B.A., B.Sc., M.I.C.E.; R. C. Mossman, F.R.Met.S., F.R.S.E.; E. B. Jamieson, M.D.; B. N. Peach, LL.D., F.R.S.; Wm. Evans, F.F.A., F.R.S.E.; R. H. Traquair, M.D., LL.D., F.R.S.; J. H. Harvey Pirie, B.Sc., M.B.; Lionel W. Hinxman, B.A., F.R.S.E.; Edward J. Bles, B.Sc.

The Secretary, Treasurer, and Librarian submitted their Annual Reports.

Harry B. Bryden, Esq., and R. B. Thomson, Esq., M.B., Ch.B., were formally admitted Fellows of the Society.

The following communications were submitted:

1. "Note on *Primnoa reseda*, Pallas, from the Færoes Channel." By Professor J. Arthur Thomson, M.A.
2. "The Mammals and Birds of Prince Charles Foreland, Spitzbergen: Notes and Exhibition of Specimens." By W. S. Bruce, Esq., F.R.S.G.S., F.R.S.E.

Monday, 17th December 1906.—Professor J. GRAHAM KERR, M.A., F.R.S.E. President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—Arthur Gofton, Esq., M.R.C.V.S.; W. A. Jolly, Esq., M.B., Ch.B.; and A. Campbell Geddes, Esq., M.B., Ch.B.

Arthur Gofton, Esq., M.R.C.V.S., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "The Embryology of *Polypterus.*" By Professor J. GRAHAM KERR, M.A., F.R.S.E.

2. "On Certain Parasitic Protozoa." By Miss MURIEL ROBERTSON. Communicated by Professor J. GRAHAM KERR.

3. "Meristic Variation in *Solaster papposus.*" By D. C. M'INTOSH, Esq., M.A., B.Sc.

Monday, 28th January 1907.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—D. C. M'Intosh, Esq., M.A., B.Sc., and R. S. Bagnall, Esq.

Wm. A. Jolly, Esq., M.B., Ch.B., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "On the Occurrence of a Supposed Australasian Hydroid (*Sertularia elongata*) in the North Sea." By JAMES RITCHIE, Esq., M.A., B.Sc. Communicated by Professor J. ARTHUR THOMSON.

2. "Exhibition, with Remarks, of Models illustrating the Development of the Mammalian Liver." By O. CHARNOCK BRADLEY, Esq. M.D., D.Sc.

3. "Exhibition of Specimens, mainly Entomological." By WM. EVANS, Esq., F.R.S.E.

Monday, 25th February 1907.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society:—Gabriel Warton Lee, Esq., D.Sc.

Richard S. Bagnall was formally admitted a Fellow of the Society.—

The following communications were submitted:

1. "Notes on the Invertebrata of the North of England, with Exhibition of certain Specimens new to the British Fauna." By R. S. BAGNALL, Esq.

2. "Note on a New and Peculiar Type of Apterous Insect (*Carinopleuris lubbocki*), a new genus and species." By R. S. BAGNALL, Esq.

3. "The Glaciers of the South Orkneys." By J. H. HARVEY PIRIE, Esq., B.Sc., M.B.

4. "Microscopic Demonstration of Transplanted Ovaries." By W. A. JOLLY, Esq., M.B., and F. H. A. MARSHALL, Esq., M.A., D.Sc.

Friday, 8th March 1907.—D. WATERSTON, Esq., M.D., F.R.S.E., Vice-President, in the Chair.

Special Meeting in the Oceanographical Laboratory, Surgeons' Hall.

The origin and objects of the laboratory were explained by W. S. Bruce, Esq., F.R.S.E., and demonstrations were given on specimens collected by Arctic and Antarctic Expeditions.

Monday, 25th March 1907.—WM EAGLE CLARKE, Esq., F.R.S.E., Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society:—John Scott Tait, Esq., C.A.

Gabriel W. Lee, Esq., D.Sc., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "Exhibition, with Remarks, of the Skull of the Okapi." By WM EAGLE CLARKE, Esq., F.R.S.E., and O. CHARNOCK BRADLEY, Esq., M.D., D.Sc.

2. "Notes on Biometry as applied to Zoology." By D. C. M'INTOSH, Esq., M.A., B.Sc.

3. "Exhibition, with Remarks, of Abnormal Specimens of *Helix* and *Astacus*." By J. H. ASHWORTH, Esq., D.Sc.

4. Exhibition, with Remarks, of Dragon Flies." By KENNETH J. MORTON, Esq., F.E.S.

SESSION CXXXVII.

Monday, 28th October 1907.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—W. F. Lanchester, Esq., M.A., and S. PACE, Esq.

The following alterations of the Laws of the Society were unanimously agreed upon:—

The first sentence of SECTION VIII. to read, "The ordinary meetings of the Society shall be held on the fourth Monday of October, November, January, February, and March, and on the third

Monday of December, at such place and at such hour as the Council shall determine; and, in the same Section, the words 'Chair taken at 7.45 P.M.,' and 'Chair taken at 8 o'clock,' to be deleted."

D. C. M'Intosh, Esq., M.A., B.Sc., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "Morphological Notes.—(*a*) The Fifth Aortic Arch of Vertebrates; (*b*) The Autostylic Skull." By Professor J. GRAHAM KERR, M.A., F.R.S.E.

2. "Variation in *Nephrops norvegicus*." By D. C. M'INTOSH, Esq., M.A., B.Sc.

3. "Dental Anomalies in the Dog." By O. CHARNOCK BRADLEY, Esq., M.D., D.Sc.

4. "Exhibits." By WM. EVANS, Esq., F.R.S.E.

Monday, 25th November 1907.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society:—D. T. Gwynne-Vaughan, Esq.

The following Office-Bearers for the Session were elected:

President—Professor J. GRAHAM KERR, M.A., F.R.S.E.

Vice-Presidents—W. S. BRUCE, LL.D., F.R.S.E.; D. WATERSTON, M.A., M.D., F.R.C.S.E., F.R.S.E.; Professor T. HUDSON BEARE., B.A., B.Sc., M.I.C.E

Secretary—O. CHARNOCK BRADLEY, M.D., D.Sc., F.R.S.E

Assistant-Secretary—J. H. ASHWORTH, D.Sc.

Treasurer—W. A. MIDDLETON, C.A.

Librarian—T. N JOHNSTON, M.B., C.M., F.R.S.E.

Councillors—E. B. JAMIESON, M.D.; B. N. PEACH, LL.D., F.R.S.; WM. EVANS, F.F.A., F.R.S.E.; R. H. TRAQUAIR, M.D., LL.D., F.R.S.; J. H. HARVEY PIRIE, B.Sc., M.D.; LIONEL W. HINXMAN, B.A., F.R.S.E.; EDWARD J. BLES, B.Sc.; WM. EAGLE CLARKE, F.L.S., F.R.S.E.; Professor J. Y. SIMPSON, D.Sc., F.R.S.E.; D. C. M'INTOSH, M.A., B.Sc., F.R.S.E.; R. STEWART MACDOUGALL, M.A., D.Sc., F.R.S.E.; KENNETH J. MORTON, F.E S.

The Secretary, Treasurer, and Librarian, submitted their Annual Reports.

W. L. Lanchester, Esq., M.A., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "Arctic Rotifers collected by Dr Wm. S. Bruce." By JAMES MURRAY, Esq.

2. "Scotia Collections.—Note on Microscopic Life in Gough Island." By JAMES MURRAY, Esq.

3. "On the Life History of *Gnorimus nobilis*, with Exhibition of the Insect and its Work." By R. STEWART MACDOUGALL, Esq., M.A., D.Sc.

4. "Exhibition of Photographs (from life) of, and Remarks on, the Californian Sea Elephant (*Macrorhinus angustirostris*), a Seal supposed, until recently, to be extinct." By WM. EAGLE CLARKE, Esq., F.R.S.E.

Monday, 16th December 1907.—Professor T. HUDSON BEARE, B.A., B.Sc., Vice-President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:— J. B. Johnston, Esq., M.B., Ch.B.; James Ritchie, Esq., M.A., B.Sc.; C. H. Morton, Esq., M.A.; Wm. Brown, Esq.; Thomas H. Bryce, Esq., M.D.; and W. F. A. Hudson, Esq., M.A.

James Ritchie, Esq., M.A., D.Sc., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "Notes on a Haplosporidian belonging to the genus *Icthyosporidium*." By Miss MURIEL ROBERTSON. Communicated by Professor J. GRAHAM KERR.

2. "Note on a Large Tubularian from the Moray Firth." By Professor J. ARTHUR THOMSON, M.A., F.R.S.E.

3. "Exhibition of Specimens." By J. H. ASHWORTH, Esq., D.Sc.

4. "Exhibition of—(*a*) a Specimen of *Trachyphloeus scabriculus*, L., showing the deciduous mandibles on the perfect insect; (*b*) Living Specimens of *Anisotoma cinnamomea*, Panz., in truffles. By Professor T. HUDSON BEARE, B.A., B.Sc., F.R.S.E.

Monday, 27th January 1908.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

Wm. Brown, Esq., and C. H. Martin, Esq., M.A., were formally admitted Fellows of the Society.

The following communications were submitted:

1. "The Mammals and Birds of Prince Charles Foreland, Spitzbergen." By W. S. BRUCE, Esq., LL.D., F.R.S.E.

2. "A Doubtful Form from the Fresh-Waters of Paraguay (*Weldonia paraguayensis*)." By C. H. MORTON, Esq., M.A.

3. "The Origin of the Nematocysts in *Microstoma lineare*." By C. H. MORTON, Esq., M.A.

4. "Exhibition of a Living *Lepidosiren*." By Professor J. GRAHAM KERR, M.A., F.R.S.E.

Monday, 24th February 1908.—WM. EVANS, Esq., F.R.S.E., in the Chair.

David A. Farquharson, Esq., M.B., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "On a Large Antipatharian from the Færoes." By Professor J. ARTHUR THOMSON, M.A., F.R.S.E.

2. "The Histology, Morphology, and Development of the Mammalian Pituitary Body." By PERCY T. HERRING, Esq., M.D. Communicated by Professor E. A. SCHÄFER.

Monday, 23rd March 1908.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

J. B. Johnston, Esq., M.B., and W. F. A. Hudson, Esq., M.A., were formally admitted Fellows of the Society.

The following communications were submitted:

1. "Lung and Swim-bladder of Fishes." By Professor J. GRAHAM KERR, M.A., F.R.S.E.

2. "Note on Palæzoic Fossils from Prince Charles Foreland, collected by Dr Wm. S. Bruce." By G. W. LEE, Esq., D.Sc.

3. "An Exhibition of Skins of the Arctic and Blue Fox, with Summer and Winter Coats, and Young." By W. S. BRUCE, Esq., LL.D., F.R.S.E.

4. "Some further Records of Collembola from the Forth Area." By WM. EVANS, Esq., F.R.S.E.

SESSION CXXXVIII.

Monday, 26th October 1908.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

The retiring Vice-President (W. S. BRUCE, Esq., LL.D., F.R.S.E.), delivered an address on "The Scientific Aspects of Polar Exploration."

Monday, 23rd November 1908.—D. WATERSTON, Esq., M.D., F.R.S.E. Vice-President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society:—Robert G. Linton, Esq., M.R.C.V.S.

The following Office-Bearers for the Session were elected:—

President—Professor J. GRAHAM KERR, M.A., F.R.S.E.

Vice-Presidents—D. WATERSTON, M.A., M.D., F.R.S.E.; Professor T. HUDSON BEARE, B.A., B.Sc., F.R.S.E.; Professor J. ARTHUR THOMSON, M.A., F.R.S.E.

Secretary—O. CHARNOCK BRADLEY, M.D., D.Sc.

Assistant-Secretary—J. H. ASHWORTH, D.Sc.

Treasurer—W. A. MIDDLETON, C.A.

Librarian—T. N. JOHNSTON, M.B., C.M., F.R.S.E.

Councillors—J. H. HARVEY PIRIE, B.Sc., M.D.; LIONEL W. HINXMAN, B.A., F.R.S.E.; WM. EAGLE CLARKE, F.L.S., F.R.S.E.; Professor J. Y. SIMPSON, D.Sc., F.R.S.E.; D. C. M'INTOSH, M.A., B.Sc., F.R.S.E.; R. STEWART MACDOUGALL, M.A., D.Sc., F.R.S.E.; KENNETH J. MORTON, F.E.S.; W. S. BRUCE, LL.D., F.R.S.E.; Professor J. COSSAR EWART, M.D., F.R.S.; E. B. BAILEY, B.A.; A. GOFTON, M.R.C.V.S.; W. A. JOLLY, M.D.

The Secretary, Treasurer, and Librarian submitted their Annual Reports.

The following communications were submitted:

1. "The Surface Details of the Bones of the Skeleton as an Index of Nutrition." By A. CAMPBELL GEDDES, Esq., M.D.

2. "Exhibition, with Remarks, of—(*a*) Snake Pipe-Fish (*Nerophis æquoreus*) recently taken near Dunbar; (*b*) *Quedius vexans, Oxypoda longipes*, and other Coleoptera from Moles' Nests in the Edinburgh District." By WM. EVANS, Esq., F.R.S.E.

3. "Exhibition, with Remarks, of Living Specimens of the Tick *Ornithodoras savignyi* from the camel, near Aden." By J. H. ASHWORTH, Esq., D.Sc.

4. "Exhibition of Reconstruction Models of a 6 mm. Embryo of *Pteromys oral.*" By O. CHARNOCK BRADLEY, Esq., M.D., D.Sc.

Monday, 21st December 1908.—W. S. BRUCE, Esq., LL.D., F.R.S.E., in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—Wm. Williamson, Esq., and Professor L. A. L. King, M.A.

Wm. Williamson, Esq., was formally admitted a Fellow of the Society.

The following communications were submitted:

1. "Is *Selaginopsis mirabilis* a British Hydroid?" By JAMES RITCHIE, Esq., M.A., B.Sc.

2. "The Generic Affinities of *Selaginopsis*." By JAMES RITCHIE, Esq., M.A., B.Sc.

3. "Medusæ and Ctenophores from the Firth of Forth." By WM. EVANS, Esq., F.R.S.E., and J. H. ASHWORTH, Esq., D.Sc.

Monday, 25th January 1909.—WM. EVANS, Esq., F.R.S.E., in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society:—John Rennie, Esq., D.Sc.; James J. Simpson, Esq., M.A., B.Sc.; J. F. Tocher, Esq., B.Sc., F.I.C.; and Henry Charles Williamson, Esq., M.A., D.Sc.

It was unanimously agreed "That women be admitted to the Ordinary Fellowship of the Society on the same terms as men."

R. G. Linton, Esq., M.R.C.V.S., and Professor L. A. L. King, M.A., were formally admitted Fellows of the Society.

The following communications were submitted:

1. "New and Curious Thysanoptera." By RICHARD S. BAGNALL, Esq.
2. "A Method of Study of the Animal Ecology of the Shore." By Professor L. A. L. KING, M.A., and E. S. RUSSELL, Esq., M.A.
3. "Exhibition of Autochrome Micro-Photographs of Hydrachnids." By WM. WILLIAMSON, Esq.

Monday, 22nd February 1909.—Professor J. GRAHAM KERR, M.A., F.R.S.E., President, in the Chair.

A. Campbell Geddes, Esq., M.D., was formally admitted a Fellow of the Society.

The following communications were submitted:—

1. "The Development of the Alimentary Canal in *Lepidosiren* and *Protopterus*." By Professor J. GRAHAM KERR, M.A., F.R.S.E.
2. "Exhibition of Figures illustrating the Development of Lungfishes, to appear in Keibel's 'Normentafeln zur Entwicklungsgeschichte.'" By Professor J. GRAHAM KERR, M.A., F.R.S.E.
3. "Humble Bees and the Pollination of *Trifolium pratense*." By R. STEWART MACDOUGALL, Esq., M.A., D.Sc.
4. "A Catalogue of Recent Cephalopoda." Second Supplement, 1897-1906. By W. E. HOYLE, Esq., D.Sc.
5. "Exhibition of—(*a*) the Cocoons of *Oiketicus platensis*, Berg., from Argentina; (*b*) Oak Timber bored by the larvæ of *Cossus ligniperda*." By R. STEWART MACDOUGALL, Esq., M.A., D.Sc.
6. "Exhibition, with Remarks, of a Photograph of a fossil Tsetse Fly (*Glossina oligocœna*) from Colorado. By J. H. ASHWORTH, Esq., D.Sc.

Monday, 22nd March 1909.—LIONEL W. HINXMAN, Esq., B.A., F.R.S.E., in the Chair.

The following were elected Ordinary Fellows of the Society:—Mrs Elizabeth Gray; Miss Marion I. Newbigin, D.Sc.; Mrs Ogilvie Gordon, D.Sc., Ph.D., F.L.S.; Miss Muriel Robertson; and Robert A. Staig, Esq.

The following communications were submitted:

1. "Oligochæta (Earth-worms and their allies) from the Forth Area." By Wm. Evans, Esq., F.R.S.E.
2. "On *Unionicola* Hald., as a valid Generic Name." By Wm. Williamson, Esq.
3. "Exhibition of Drawings and Microscopic Preparations of the British Species of *Unionicola* Hald." By Wm. Williamson, Esq.
4. "Note on *Alysia manducator*, Panz." By R. Stewart MacDougall, Esq., M.A., D.Sc.
5. "On the Length of the Life Cycle in *Myospila meditabunda*, Fab., *Borborus equinus*, Fln., and *Camptocladius aterrimus*, Mg." By R. Stewart MacDougall, Esq., M.A., D.Sc.
6. "Variation in *Aurelia aurita*." By D. C. M'Intosh, Esq., M.A., B.Sc.

LIST OF SOCIETIES WHICH RECEIVE THE SOCIETY'S "PROCEEDINGS."

Those Institutions from which Publications are received in return are indicated by an asterisk.

ENGLAND.

BIRMINGHAM, . .	*Philosophical Society, King Edward's Grammar School.
Do. . .	*Natural History Society, Sir Josiah Mason's College.
CAMBRIDGE, . .	*Philosophical Society.
Do. . .	University Library.
CIRENCESTER, .	*Editor of the *Agricultural Students' Gazette.*
NEWCASTLE-ON-TYNE, . . .	Armstrong College.
HALIFAX, . .	*Yorkshire Geological and Polytechnic Society.
LEEDS, . .	*The Conchological Society of Great Britain and Ireland.
LIVERPOOL, . .	*Biological Society, University College.
Do. . .	*Literary and Philosophical Society.
Do. . .	*Engineering Society, Royal Institution.
LONDON, . .	British Museum Library.
Do. . .	*British (Natural History) Museum, South Kensington.
Do. . .	*Royal Society, Burlington House, Piccadilly, W.
Do. . .	Chemical Society, Burlington House, Piccadilly, W.
Do. . .	*Geological Society, Burlington House, Piccadilly, W.
Do. . .	*Linnean Society, Burlington House, Piccadilly, W.
Do. . .	*Royal Microscopical Society, King's College.
Do. . .	Museum of Economic Geology, Jermyn Street.
Do. . .	Editor of *Nature*, 29 Bedford Street, Covent Garden.
Do. . .	*Zoological Society, Hanover Square.
Do. . .	*Geologists' Association, University College, W.C.
MANCHESTER, .	*Geological Society, 36 George Street.
Do. . .	*Literary and Philosophical Society, 36 George Street.
Do. . .	The Victoria University.
NORWICH, . .	*Norfolk and Norwich Naturalists' Society, The Museum.
OXFORD, . .	The Bodleian Library.
TRURO, . .	*Royal Institution of Cornwall.
WATFORD, . .	*Hertfordshire Natural History Society and Field Club.

SCOTLAND.

ABERDEEN, . .	University Library.
COCKBURNSPATH, .	*Berwickshire Naturalists' Field Club, Old Cambus.
EDINBURGH, . .	Advocates' Library.
Do. . .	University Library.
Do. . .	*Royal Society.
Do. . .	Royal Medical Society.

EDINBURGH, . .	*Royal Scottish Society of Arts.
Do. . .	*Royal Scottish Geographical Society.
Do. . .	*Botanical Society.
Do. . .	*Highland and Agricultural Society.
Do. . .	*Geological Society.
GLASGOW, . .	*Philosophical Society.
Do. . .	*Natural History Society.
Do. . .	*Geological Society.
Do. . .	*Andersonian Naturalists' Society.
Do. . .	Glasgow and West of Scotland Technical College, Glasgow.
Do. . .	University Library.
PERTH, . . .	*Perthshire Society of Natural History.
ST ANDREWS, . .	University Library.

IRELAND.

BELFAST, . .	*Natural History and Philosophical Society.
DUBLIN, . .	*Royal Irish Academy.
Do. . .	*Royal Dublin Society.
Do. . .	*Royal Geological Society of Ireland.

HOLLAND.

AMSTERDAM, . .	*De Koninklijke Akademie van Wetenschappen.
LEYDEN, . .	*Museum van Naturlijke Histoire.
UTRECHT, . .	Provinciaal Genootschap an Kunsten en Wetenschappen.

SWITZERLAND.

BASLE, . . .	*Die Naturforschende Gesellschaft.
BERN, . .	*Allgemeine Schweizerische Gesellschaft für die gesammten Naturwissenschaften.
Do. . . .	*Die Naturforschende Gesellschaft.
GENEVA, . .	*Société de Physique et d'Histoire Naturelle.
NEUFCHATEL, .	*Société des Sciences Naturelles.
ZÜRICH, . . .	*Die Naturforschende Gesellschaft.

GERMANY.

BERLIN, . . .	*Königliche Akademie der Wissenschaften.
Do. . . .	*Deutsche Geologische Gesellschaft.
Do. . . .	*Gesellschaft Naturforschender Freunde.
BONN, . . .	*Naturhistorischer Verein der preussischen Rheinlande Westfalens, und des Reg.-Bezirks Osnabrück.
BREMEN, . .	*Verein für Naturwissenschaft.
BRESLAU, . .	*Schlesische Gesellschaft für Vaterländische Cultur.
BRUNSWICK, . .	*Naturwissenschaftlicher Verein.
DRESDEN, . .	Königliche Sammlungen für Kunst und Wissenschaft.
Do. . .	*Der Verein für Erdkunde.
ELBERFELD, . .	*Naturwissenschaftlicher Verein.
ERLANGEN, . .	University Library.
FRANKFORT-ON-MAIN,	*Senckenbergische Naturforschende Gesellschaft.
Do.	*Deutsche Malakozoologische Gesellschaft, Dr Kobelt. Schwanheim.
FREIBURG, i. B., .	*Die Naturforschende Gesellschaft.
GÖTTINGEN, . .	*Königliche Gesellschaft der Wissenschaften.

HALLE, . . .	*Kaiserliche Akademie der Naturforscher.
HAMBURG, . .	Naturhistorisches Museum.
JENA, . . .	*Medicinisch-naturwissenschaftliche Gesellschaft.
LEIPZIG, . .	*Königliche Sächsische Gesellschaft der Wissenschaften.
Do. . . .	Naturforschende Gesellschaft.
Do. . . .	Editor of the *Zoologischer Anzeiger.*
MUNICH, . .	*Königliche Baierische Akademie der Wissenschaften.
STUTTGART, . .	*Verein für Vaterländische Cultur in Württemberg.
WÜRZBURG, . .	*Physikalisch-medicinische Gesellschaft.

AUSTRIA.

AGRAM, . . .	*Societas Croatica Historico-naturalis.
HERMANNSTADT, .	*Siebenbürgischer Verein für Naturwissenschaft.
PRAGUE, . .	*Königliche-böhmische Gesellschaft der Wissenschaften.
TRIESTE, . .	Società Adriatica di Scienze Naturali.
VIENNA, . .	*K.k. zoologisch-botanische Gesellschaft.
Do. . .	*K.k. Naturhistorisches Hof-Museum.

ITALY.

BOLOGNA, . .	*Accademia delle Scienze dell' Istituto.
MILAN, . . .	*Reale Istituto Lombardo di Scienze, Lettere ed Arti.
Do. . . .	*Società Italiana di Scienze Naturali.
MODENA, . .	Società dei Naturalisti.
NAPLES, . .	Editor of the *Zoologischer Jahresbericht*, Zoological Station.
PADUA, . . .	*Società Veneto-Trentina di Scienze Naturali residente in Padova.
ROME, . . .	*Reale Accademia dei Lincei.
TURIN, . . .	*Reale Accademia delle Scienze.

SPAIN.

MADRID, . .	*Real Academia de Ciencias exactas, fisicas e naturales.
Do. . .	*Sociedad española de Historia natural.

PORTUGAL.

COIMBRA, . .	*Bibliothèque de l'Université.
LISBON, . .	*Academia Real das Sciencias.

FRANCE.

BORDEAUX, . .	La Société Linnéenne.
CAEN, . . .	*Société Linnéenne de Normandie.
CHERBOURG, . .	*Société Nationale des Sciences Naturelles.
PARIS, . . .	*Académie des Sciences de l'Institut.
Do. . . .	*Société Géologique de France, Rue des grands Augustins, 7.
Do. . . .	*Société Zoologique de France, Rue des grands Augustins, 7.
Do. . . .	Société de Biologie.
Do. . . .	Ecole des Mines.

BELGIUM.

BRUSSELS, . .	*Académie Royale des Sciences, des Lettres, et des beaux Arts.
Do. . .	*Société Royale Malacologique de Belgique.
Do. . .	Société Belge de Microscopie.

NORWAY.

BERGEN, . .	*The Museum.
CHRISTIANIA, .	*Professor Dr N. Wille, "Nyt Magazin for Naturvidenskaberne," Christiania, Norway.
Do. . .	Universitets Bibliothek.

DENMARK.

COPENHAGEN, .	*Kongelige Danske Videnskabernes Selskab.
Do. . .	*Naturhistoriske Forening.

SWEDEN.

STOCKHOLM, . .	*Kongliga Svenska Vetenskaps-Akademie.
UPSALA, . .	*Kongliga Vetenskaps-Societeten.
Do. . .	*Observatoire Météorologique.

RUSSIA.

DORPAT, . .	*Naturforscher Gesellschaft.
KIEV, . . .	*Natural History Society.
MOSCOW, . .	*Société Impériale des Naturalistes.
ST PETERSBURG, .	*Académie Impériale des Sciences.
Do. .	*Imperial Botanic Garden.

AMERICA.

UNITED STATES.

ALBANY, N. Y., .	*New York State Library.
BALTIMORE, . .	*Johns-Hopkins University Library.
BOSTON, . .	*American Academy of Arts and Sciences.
Do. . .	*Society of Natural History.
BROOKVILLE, IND.,	*Brookville Society of Natural History.
CALIFORNIA, . .	University of California
CAMBRIDGE, MASS.,	*Harvard University Library.
Do.	*Museum of Comparative Zoology.
CHICAGO, . .	*Academy of Sciences.
CINCINNATI, . .	*Society of Natural History.
NEWHAVEN, CONN.,	*Connecticut Academy of Arts and Sciences.
Do.	Yale College Library.
NEW YORK, . .	*New York Academy of Sciences.
PHILADELPHIA, .	*Academy of Natural Sciences.
Do. .	*Wagner Free Institute.
SAN FRANCISCO, .	*California Academy of Sciences.
ST LOUIS, . .	*Academy of Sciences.
WASHINGTON, .	*Smithsonian Institute.
Do. . .	*Philosophical Society.
Do. .	*United States National Museum.
Do. .	*United States Geological Survey.
Do. . .	*United States Commissioner of Fish and Fisheries.
WISCONSIN, . .	*Academy of Sciences, Arts, and Letters.

MEXICO.

MEXICO, . .	*Ministerio de Fomento de la Republica, Osservatorio Meteorologico.
Do. . .	*Sociedad Cientifica, "Antonio Alzate," Osservatorio Meteorologico Central.

CANADA.

HAMILTON, . .	*The Hamilton Association.
KINGSTON, . .	*Queen's University.
MANITOBA, . .	*Historical and Scientific Society, Winnipeg.
MONTREAL, . .	*The Natural History Society.
OTTAWA, . .	*Canadian Geological Survey.
Do. . .	*Royal Society of Canada.
TORONTO, . .	*The Canadian Institute.

NOVA SCOTIA.

HALIFAX, . .	*Nova Scotia Institute of Natural Science.

BRAZIL.

RIO DE JANEIRO, .	Museu Nacional.
Do. .	Instituto de Manguinhos caixa 926 Rio de Janeiro, Brazil.

AFRICA.

CAPE TOWN, . .	*South African Philosophical Society.

ASIA.

BATAVIA . .	*Koninklijke Natuurkundige Vereeniging in Nederlandsch Indie.
CALCUTTA, . .	Royal Asiatic Society of Bengal.
TOKIO, JAPAN, .	*Imperial University of Japan.

AUSTRALASIA.

ADELAIDE, . .	*Royal Society of South Australia.
MELBOURNE, . .	*Royal Society of Victoria.
SYDNEY, . .	*Royal Society of New South Wales.
Do. . .	*The Australian Museum.
Do. . .	*Linnean Society of New South Wales.
WELLINGTON, .	*New Zealand Institute.

LIST OF FELLOWS

At 1st October 1909.

*Those marked * are Life Members.*

Date of Election.

1905. Agar, W. E., B.A., D.Sc., 1 Eton Gardens, Hillhead, Glasgow.
1905. Anderson, T. J., B.Sc., College of Agriculture and Horticulture, Holmes Chapel, Cheshire.
1901. Annandale, Nelson, B.A., D.Sc., The Museum, Calcutta.
1884. Armitage, J. A., B.A., 58 Waterloo Road South, Wolverhampton.
1902. *Ashworth, J. H., D.Sc., Zoological Laboratory, University.
1907. *Bagnall, R. S., The Groves, Winlaton-on-Tyne.
1904. Bailey, Edward B., B.A., H.M. Geological Survey, 33 George Square.
1885. Barbour, A. H. F., M.A., B.Sc., M.D., 4 Charlotte Square.
1904. Beare, Professor T. Hudson, B.A., B.Sc., M.I.C.E., University.
1880. *Beddard, Frank E., M.A., F.R.S., Zoological Gardens, London.
1881. *Berry, W., Tayfield, Newport, Fife.
1898. Bisset, James, M.A., F.L.S., F.G.S., 9 Greenhill Park.
1902. Black, J. Wyclif, F.C.S., 20 Mardale Crescent.
1903. Bles, Edward J., M.A., D.Sc., The Mill House, Iffley, Oxford.
1906. *Bowhill, Jas. Wm., B.A., Morelands, Grange Loan.
1892. Bowhill, Thomas, F.R.C.V.S., 1445 6th Avenue, Fairview, Vancouver, British Columbia.
1893. *Bradley, O. Charnock, M.D., D.Sc., F.R.S.E., Royal Veterinary College—*Secretary*.
1876. Brown, J. A. Harvie-, F.Z.S., F.R.S.E., Dunipace House, Larbert.
1891. Brown, Richard, C.A., 23 St Andrew Square.
1904. Brown, R. N. Rudmose, B.Sc., 52 Beaconsfield Place, Aberdeen.
1907. Brown, Wm., M.R.C.V.S., Catterloch, Banchory, by Aberdeen.
1876. *Bruce, W. P., Kinleith Mill, Currie.
1894. Bruce, W. S., LL.D., F.R.S.E., F.R.S.G.S., Scottish Oceanographical Laboratory, Surgeons' Hall.
1907. Bryce, T. H., M.D., 2 Granby Terrace, Glasgow, W.
1906. Bryden, H. B., 16 Frederick Street.
1885. Burt, Robert F., M.B., 76 Stapleton Hall Road, Stroud Green, London, N.
1893. Campbell, Kenneth Findlater, C.E., Hon.M.Inst.C.E., M.S.I., Town Hall, Huddersfield.
1892. Carlier, Edmond W. Wace, B.Sc., M.D., University, Birmingham.
1876. *Carmichael, Sir T. D. Gibson, Malleny, Balerno, Midlothian.
1858. Carruthers, W., F.R.S., 14 Vermont Road, Norwood, London, S.E.
1888. Clarke, Wm. Eagle, F.L.S., F.R.S.E., Royal Scottish Museum.
1895. *Clough, C. T., M.A., H.M. Geological Survey, 33 George Square.
1881. Cook, C., W.S., 11 Belgrave Crescent.

Date of Election.

1902. Cowan, Francis, C.A., Westerlea, Murrayfield.
1897. Craig, E. H. Cunningham, B.A., F.G.S., Port of Spain, Trinidad.
1900. *Crampton, Cecil B., M.B., C.M., H.M. Geological Survey, 33 George Square.
1874. Crawford, W. C., M.A., 1 Lockharton Gardens, Colinton Road.
1877. *Dalgleish, J. J., Brankston Grange, Bogside Station, Alloa.
1894. Day, T. Cuthbert, F.C.S., 36 Hillside Crescent.
1895. Douglas, William, 9 Castle Street.
1880. Drummond, W., S.S.C., 4 Learmonth Terrace.
1902. Dunstan, John, M.R.C.V.S., F.R.S.E., Liskeard, Cornwall.
1903. Edmunds, Arthur C., 10 Bright's Crescent.
1889. Elsworth, R. C., M.D., F.R.C.S.Eng., St Helen's Road, Swansea.
1880. *Evans, Wm., F.F.A., F.R.S.E., 38 Morningside Park.
1883. Ewart, Professor J. Cossar, M.D., F.R.S., University.
1902. Farquharson, David A., M.B., C.M., Royal Veterinary College.
1884. *Ferguson, James A. E., M.B., Eccles, East Bank, Demerara, British Guiana.
1885. Ferguson, James Haig, M.D., F.R.C.P.E., 7 Coates Crescent.
1895. Flett, John Smith, M.B., D.Sc., Museum of Practical Geology, Jermyn Street, London.
1906. Geddes, A. Campbell, M.D., Anatomy Department, University.
1906. Gofton, A., M.R.C.V.S., Royal Veterinary College.
1909. Gordon, Mrs Ogilvie, D.Sc., Ph.D., F.L.S., 1 Rubislaw Terrace, Aberdeen.
1909. Gray, Mrs Elizabeth, 59 George Street.
1877. Grieve, Somerville, 21 Queen's Crescent.
1886. Grieve, Symington, 11 Lauder Road.
1893. Grimshaw, Percy H., F.E.S., Royal Scottish Museum.
1893. *Guppy, H. B., M.B., F.R.S.E., E.M.A., Pearl Harbour, Sandwich Islands.
1899. Hay, Wm. Peach, M.B., C.M., Lincoln Road, Peterborough.
1905. Henderson, D. W., M.A., Zoological Laboratory, University.
1883. Henderson, Professor, M.B., F.L.S., Christian College, Madras, India.
1883. Hepburn, Professor David, V.D., M.D., C.M., M.R.C.S. (Eng.), F.R.S.E., University College, Cardiff.
1899. Heslop, Charles, Lothian Vale, Holyrood.
1884. Hinxman, Lionel W., B.A., F.R.S.E., H.M. Geological Survey, 33 George Square.
1878. Horne, J., LL.D., F.G.S., F.R.S., H.M. Geological Survey, 33 George Square.
1883. Hoyle, W. E., M.A., D.Sc., F.R.S.E., National Museum of Wales, City Hall, Cardiff.
1907. Hudson, W. F. A., M.A., 6 Wollaston Road, Cambridge.
1904. Ingram, B., F.R.C.S.E., Hamilton, Victoria, Australia.
1903. Jamieson, E. B., M.D., Anatomy Department, University.
1895. *Johnston, Surgeon-Major Henry Halcro, D.Sc., M.D., F.L.S., Orphir House, Orphir, Kirkwall, Orkney.

Date of Election.

1907. Johnston, J. B., M.B., Ch.B., 21 St Catherine's Place.
1898. Johnston, T. Nicol, M.B., C.M., F.R.S.E., Corstorphine House, Corstorphine—*Librarian.*
1894. Johnstone, Lieut. George, R.N.R., F.R.S.G.S., F.R.P.S., 26 Comiston Drive.
1906. Jolly, W. A., M.B., Ch.B., Physiological Laboratory, University.
1869. *Kennedy, Rev. J., M.A., B.D., 9 Hartington Place.
1892. Kerr, Professor J. Graham, M.A., F.R.S., University, Glasgow.
1905. Kerr, John, Sunnybrae, Corstorphine.
1878. Kidston, Robert, LL.D., F.R.S.E., 12 Clarendon Place, Stirling.
1908. King, Professor L. A. L., M.A., St Mungo's College, Glasgow.
1904. *Kinnear, Norman B., Mem. Brit. Orn. Union, Bombay Natural History Society, Apollo Street, Bombay.
1907. Lanchester, W. F., M.A., Den of Gryffe, Kilmacolm.
1907. Lee, G. Warton, D.Sc., H.M. Geological Survey, 33 George Square.
1902. *Leigh, J. Hamilton, F.L.S., F.Z.S., Matchams Park, Ringwood, Hants.
1903. Leighton, Gerald R., M.D., F.R.S.E., Sunnyside, Trinity.
1908. Linton, R. G., M.R.C.V.S., Combe Martin, N. Devon.
1861. Logan, A., Register House.
1886. M'Cracken, Professor, Crewe.
1882. *M'Donald, L. M., Skaebost, Skye.
1896. *MacDougall, R. Stewart, M.A., D.Sc., F.R.S.E., 13 Archibald Place.
1900. M'Gillivray, W. L., Eoligary, Barra.
1907. M'Intosh, D. C., M.A., B.Sc., Edinburgh Ladies' College, Queen Street.
1893. Mackay, Alexander, Bank of Scotland, Thurso.
1904. Mackie, N. Alex., 13 Barnton Terrace.
1886. MacWatt, Major R. C., M.A., M.B., c/o Messrs King, King and Co., Bombay.
1901. Marshall, F. H. A., B.A., D.Sc., F.R.S.E., Christ's College, Cambridge.
1906. Marshall, James R., Rachan, Broughton, Peeblesshire.
1907. Martin, C. H., M.A., Natural History Department, University, Glasgow.
1903. Middleton, W. A., C.A., 5 N. St David Street—*Treasurer.*
1889. *Millar, Robert C., C.A., 30 York Place.
1898. Miller, Hugh, F.Z.S., Zoological Laboratory, 29 George Square.
1898. Morton, Alexander, B.A., B.Sc., 21 Woodburn Terrace.
1898. Morton, Kenneth J., F.E.S., 13 Blackford Road.
1890. Mossman, R. C., F.R.Met.S., F.R.S.E., 10 Blacket Place.
1895. Munro, Robert, M.A., M.D., LL.D., F.R.S.E., F.S.A.(Scot.), Elmbank, Largs, Ayrshire.
1874. Murray, D. R., M.B., C.M., 41 Albany Street, Leith.
1905. Murray, James, Invermay, Park Road, Maxwelltown, Dumfries.
1877. Murray, Sir John, K.C.B., Ph.D., LL.D., F.L.S., F.R.S.E., Challenger Lodge, Wardie.
1889. Musgrove, Professor James, M.D., University, St Andrews.

Date of Election.

1904. Nash, J. Kirke, L.D.S., 21 Alva Street.
1909. Newbigin, Miss Marion J., D.Sc., 12 Greenbank Place.
1887. Norman, Rev. Canon, M.A., D.C.L., The Red House, Berkhamstead, Herts.
1907. Pace, S., Milneholm, Hounslow, Middlesex, and 6 Provost Road, Haverstock Hill, London, N.W.
1870. Peach, B. N., LL.D., F.G.S., F.R.S., 72 Grange Loan.
1904. Pirie, J. H. Harvey, B.Sc., M.D., Ch.B., 13 Alva Street.
1889. Purvis, G. Carrington, B.Sc., M.D., Bacteriological Institute, Graham's Town, Cape Colony.
1885. Raeburn, Harold, Raeburn's Brewery, Duddingston.
1881. *Ramsay, Lieut.-Col. Wardlaw, Whitehill, Rosewell, Midlothian.
1909. Rennie, John, D.Sc., 60 Desswood Place, Aberdeen.
1907. Ritchie, James, M.A., B.Sc., Royal Scottish Museum.
1909. Robertson, Miss Muriel, Lister Institute, Chelsea, London.
1861. *Robertson, T., The Gables, East Berghalt, Suffolk.
1894. Roebuck, W. Denison, F.L.S., 259 Hyde Park Road, Leeds.
1900. Schäfer, Professor E. A., LL.D., F.R.S., University.
1889. Scott, Thomas, LL.D., F.L.S., 280 Victoria Road, Aberdeen.
1909. Simpson, James J., M.A., B.Sc., Zoological Laboratory, University, Aberdeen.
1902. *Simpson, Professor J. Y., D.Sc., F.R.S.E., 25 Chester Street.
1886. *Somerville, Professor Wm., M.A., B.Sc., F.L.S., F.R.S.E., 121 Banbury Road, Oxford.
1880. Sprague, T. Bond, M.A., LL.D., F.R.S.E., 29 Buckingham Terrace.
1909. Staig, Robert A., Natural History Department, University, Glasgow.
1899. Stenhouse, Andrew G., 191 Newhaven Road, Leith.
1900. *Tait, David, H.M. Geological Survey, 33 George Square.
1907. Tait, J. S., 10 Drumsheugh Place.
1894. Taylor, William, Lhanbryde, Elgin.
1893. Terras, James A., B.Sc., 40 Findhorn Place.
1887. Thomson, Professor J. Arthur, M.A., F.R.S.E., University, Aberdeen.
1876. *Thomson, John.
1906. Thomson, R. B., M.B., Ch.B., Anatomy Department, University.
1909. Tocher, J. F., B.Sc., F.I.C., 5 Chapel Street, Peterhead.
1885. Tomlinson, Henry T., M.B., C.M., Coton Road, Nuneaton.
1859. Traquair, R. H., M.D., LL.D., F.R.S., The Bush, Colinton.
1905. Troup, R. D. R., St Cuthbert's Lodge, Wells, Somerset.
1858. *Turner, Sir Wm., K.C.B., M.B., D.Sc., D.C.L., LL.D., F.R.S., 6 Eton Terrace.
1907. Vaughan, D. T. Gwynne, Birkbeck College, Chancery Lane, London, E.C.
1905. Vickers, H. Maxwell.
1901. Waddell, James Alexander, of Leadloch, 12 Kew Terrace, Glasgow.
1882. Wallace, Professor R., University.
1898. Waterston, David, M.A., M.D., F.R.C.S.E., F.R.S.E., Anatomy Department, University.

Date of Election.

1894. Whitaker, J. Ryland, B.A., M.B., L.R.C.P.E., Anatomy Department, Surgeons' Hall.

1884. White, J. Martin, of Balruddery, Dundee; 1 Cumberland Place, Regent's Park, London.

1890. Williams, John Robert, M.B., C.M., Ardre, Penmaenmawr.

1909. Williamson, Henry Chas., M.A., D.Sc., 28 Polmuir Road, Aberdeen.

1908. Williamson, Wm., 4 Meadowbank Terrace.

1895. *Wilson, Professor Gregg, Ph.D., D.Sc., University, Belfast.

1883. *Woodhead, Professor G. Sims, M.D., F.R.S.E., University, Cambridge.

1896. Yeoman, John B., M.B., C.M., Neston, Cheshire.

CORRESPONDING.

Date of Election.

Andrew, Rev. J., Newbury Fifeshire.
1875. Coughtrey, Professor Millen, M.D., University of Otago, New Zealand.
1858. Duncan, Rev. J., Denholm.
1870. Fraser, Rev. Samuel, Melbourne.
1871. Grieve, A. F. Brisbane, Queensland.
1852. Howden, J. C., M.D., Montrose.
1874. Joass, Rev. J. M., LL.D., Golspie.
1874. Jolly, William.
1885. Lindström, Professor Gustav, Stockholm.
1871. Macdonald, John, S.S.C., 19 York Place, Edinburgh.
Mushet, David, Gloucester.
1885. Nathorst, Professor A. G., Surveyor-General, Geological Survey of Sweden, Stockholm.
1867. Robb, Rev. Alexander, Old Calabar.

HONORARY.

1857. Chevrolat, Auguste, Paris.
1865. Colloredo-Mannsfeldt, Prince, Vienna.
1857. Dohrn, C. A., Zoological Station, Naples.
1883. Geikie, Sir Archibald (Ord. Fellow 1878), London, *Olim Præses.*
1895. Geikie, Professor James, LL.D., D.C.L., F.R.S., University, Edinburgh.
1857. Gerstaecker, A. Griefswald.
1857. Javet, Charles, Paris.
1857. Kraatz, G., Berlin.
1888. Lankester, Professor Sir E. Ray, K.C.B., F.R.S., London.
1893. Lapworth, Professor, F.R.S., Birmingham.
1857. Obert, M., St Petersburg.
1888. Vines, Sydney H., M.A., F.R.S., Christ's College, Cambridge.

Fellows are requested to intimate change of Address to
O. CHARNOCK BRADLEY, *Secretary,*
ROYAL VETERINARY COLLEGE, EDINBURGH.

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